DRC Automatic Back Gauge System for Press Brakes

Operators Manual

Precision Measurement Division
Dynamics Research Corporation

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1. GENERAL SYSTEM DESCRIPTION

The DRC Automatic Back Gauge System positions a back gauge to a preprogrammed position for each operation of the press brake. The total system consists of a digital controller with a mounting arm, a motorized mechanical back gauge with mounting supports, and a servo power supply, all ready for easy mounting on a press brake.

The 90 step capacity of the digital controller is organized into ten separate blocks of nine sequential steps each. A step contains all the information needed for a bend including the dimension, the number of cycles (repeat of any one dimension), and the depth (operative only when used on a brake that is equipped with electrical switches for multiple depth control). Each of the ten blocks has the capacity to present up to nine different dimensions with up to nine repeats or cycles of each different dimension. Additionally, program blocks can be automatically addressed by information within another block, providing the ability to perform one long program of up to 72 different dimensions.

The motorized mechanical back gauge consists of under table castings and upper carriage castings, a direct drive motor, a single screw vertical adjustment, a solid shaft linear actuator, a direct reading linear encoder, a coarse and fine reference bar adjustment, and flip-up gauge stops. The power supply and associated electrical circuitry for the closed-loop servo is enclosed with brackets for mounting to the side of the press brake. A gauge advancement switch with brackets is furnished. When mounted it will signal the controller when the ram is in its up position. Two reference bars are provided to permit the operator to calibrate the dimensional accuracy of the back gauge.

2. INSTALLATION

2.1 ATTACHMENT OF DIGITAL CONTROLLER AND BACK GAUGE POWER SUPPLY ENCLOSURE

The DRC Automatic Back Gauge System is furnished with a display arm on which the digital controller is mounted. The display arm can be mounted to either side frame. However, on most press brakes the left side frame is preferable because it is clear of controls and electrical switch boxes.

Drill and tap four (4) 5/16-18 (m 8) holes in the side frame as shown in Figure 2-1.

> CAUTION: Care should be taken to properly adjust the arm stop to prevent the arm from being struck by the ram.

A complete installation of the display arm is shown in Figure 2-2.

The servoamplifier is mounted just below the Display Arm in a conveniently clear area on the side frame as shown in Figure 2-3. Drill and tap two (2) 5/16-18 (m 8) holes in the side frame as shown in Figure 2-4.

Remove the cover of the servoamplifier to gain access to the mounting holes in the servoamplifier frame. Mount the servoamplifier to the side frame using two (2) 5/16-18 (m 8) bolts and washers provided. Mount the frame so that the connectors point downward toward the floor. Replace the servoamplifier cover after mounting is completed, as shown in Figure 2-5.

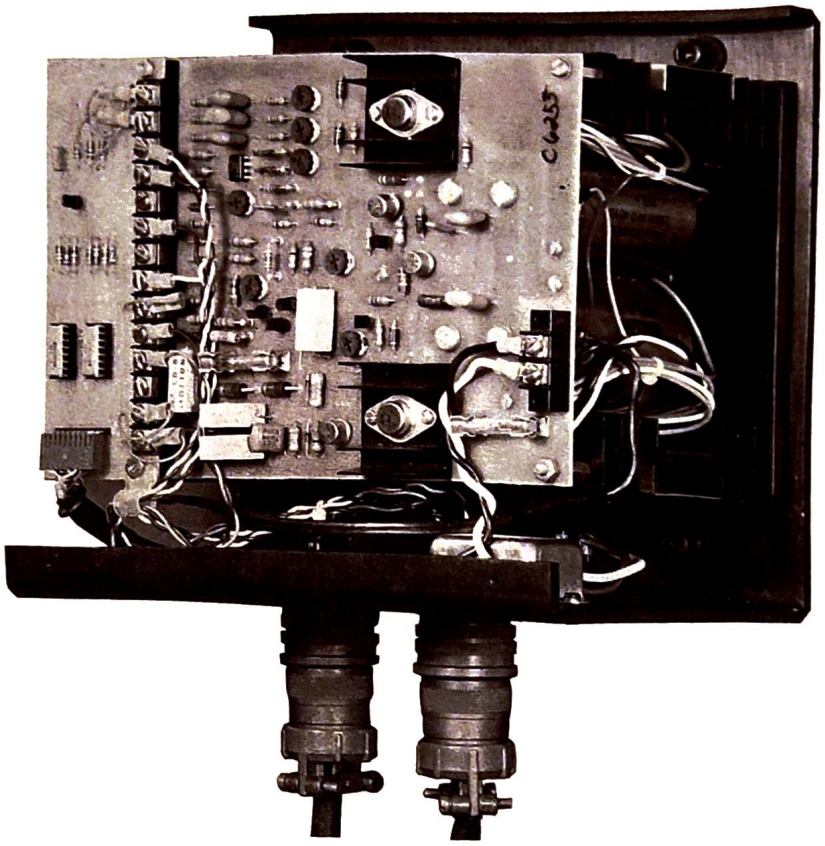


Figure 2-3. Servoamplifier Installation

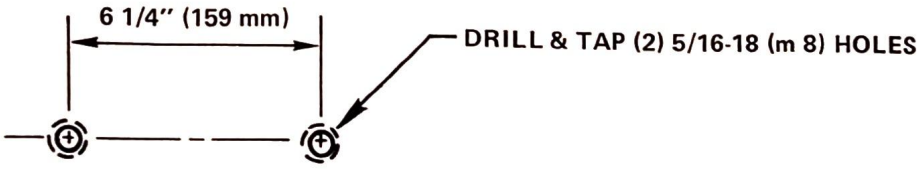


Figure 2-4

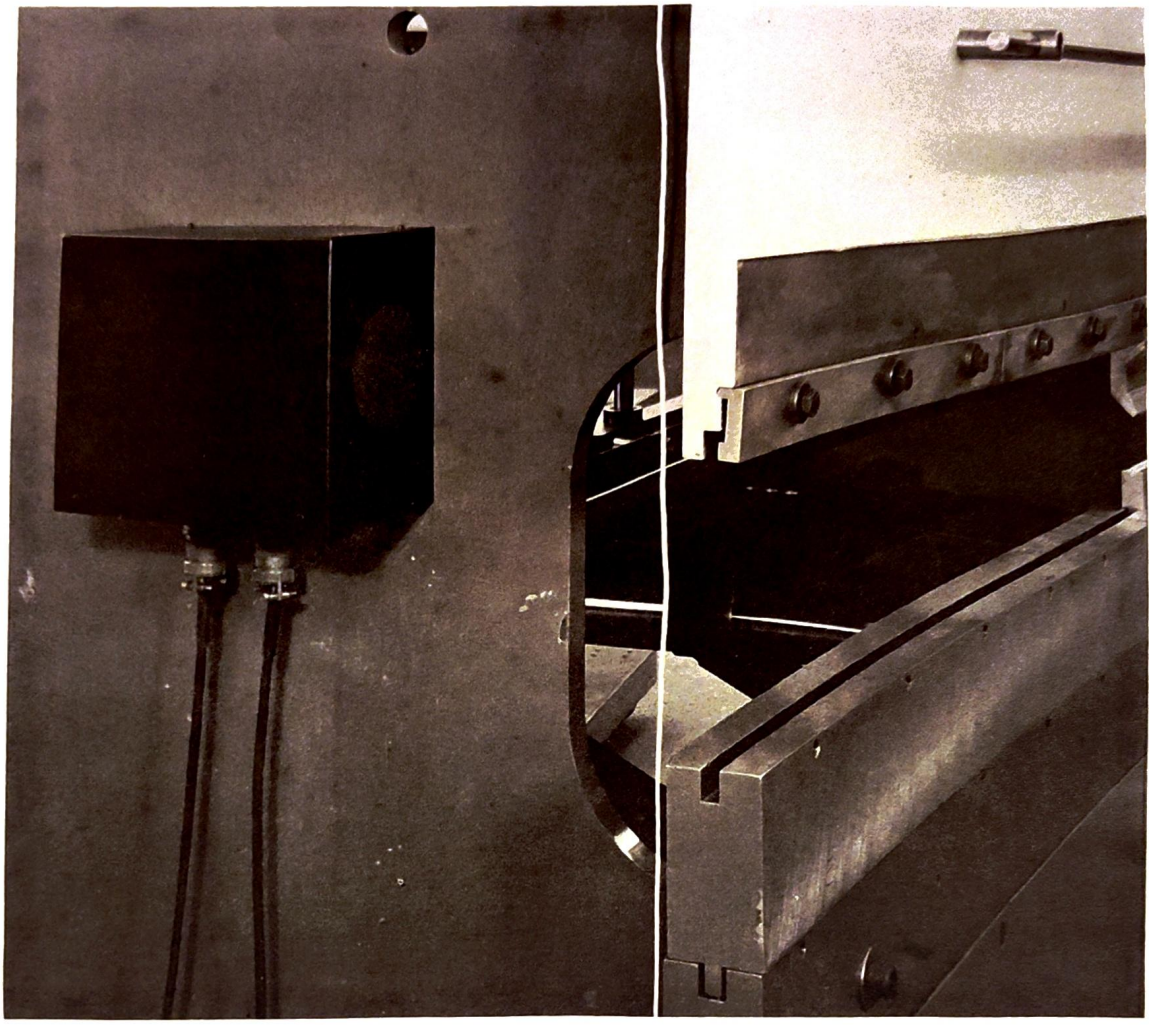


Figure 2-5. Servoamplifier with Cover

2.2 ATTACHMENT OF GAUGE SYSTEM ADVANCEMENT SWITCH

A limit switch is mounted to the press brake side frame in such a manner that it will be actuated and electrically closed when the brake ram is in the up position (see Figure 2-6) and electrically open otherwise.

Mount the trip roller on top of the ram by drilling and tapping two (2) 8-32 (m 4) holes. To properly spot the two holes, proceed as follows:

1. Mount the switch on the switch bracket.
2. Hold the switch bracket against the outside face of the press brake side frame.

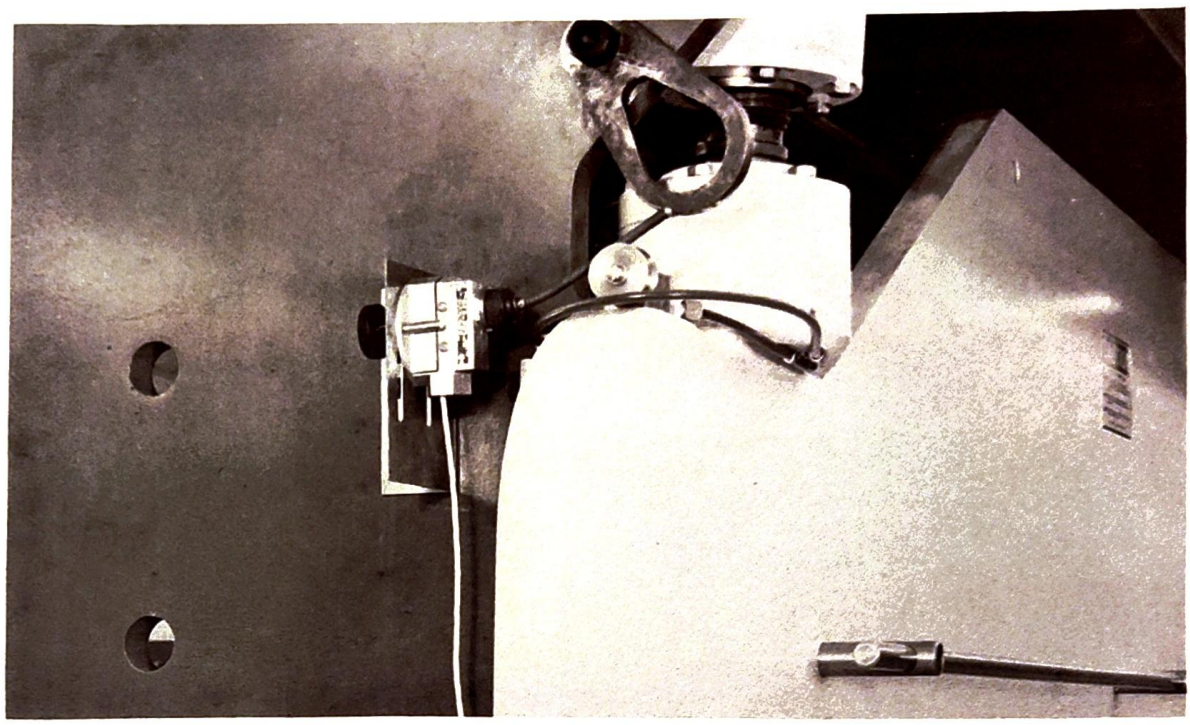


Figure 2-6. Gauge Advancement Switch Actuated and Electrically Closed with Ram in the Up Position

3. Position the trip roller on top of the ram such that the switch actuator fits inside the trip roller groove.

4. Mark and spot the location of the holes to be tapped on the top of the ram by transferring the position from the clearance holes in the trip roller mounting block.

The limit switch is vertically adjustable by the use of two large knurled thumb knobs, shown in Figure 2-7. The limit switch should be vertically positioned so that it is activated when the ram is at the maximum top of its stroke and is not activated when the ram is not at the top of its stroke.

Mount the limit switch bracket by drilling and tapping two (2) 5/16-18 (m 8) holes in the outside face of the press brake side face. To properly spot the two holes, proceed as follows:

1. Adjust the press brake to maximum top stroke of the ram.

2. Adjust the limit switch to the top position on the bracket by using the two knurled knobs.

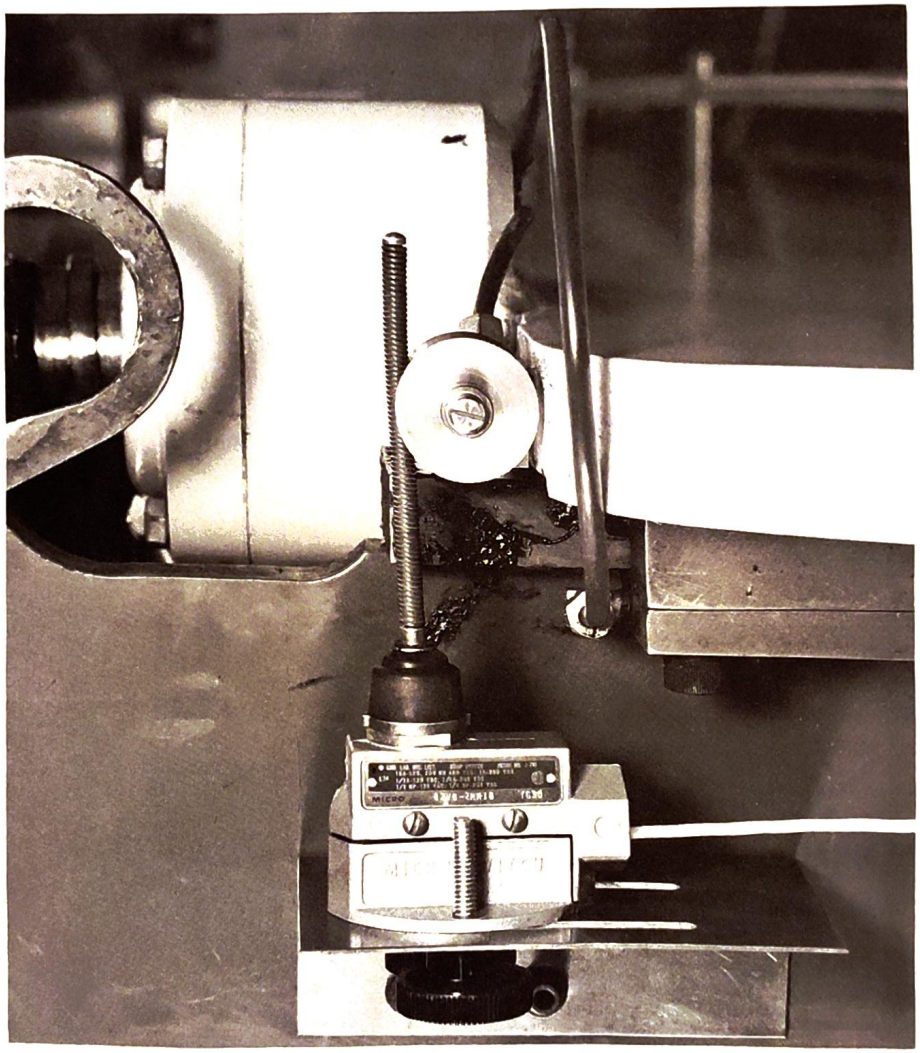


Figure 2-7. Gauge Advancement Switch with Thumb Knobs

3. Locate the limit switch bracket on the side frame such that the actuator is in the roller groove and the switch is electrically closed.

4. Mark and spot the location of the holes to be tapped in the side frame by transferring the position from the clearance holes in the limit switch bracket.

2.3 ATTACHMENT OF BACK GAUGE TO PRESS BRAKE

The DRC Automatic Back Gauge mechanism is mounted to the bed of the press brake with two (2) 3/4-inch (m 18) bolts. The distance from the center line of the two (2) 3/4-inch (m 18) mounting bolts to the bottom of the Flip-Up Gauge Stops, when the Gauge Bar is set at the center of its vertical adjustment, is 11 3/4-inch (298 mm) (see Figure 2-8). The Gauge Bar is adjustable up or down 3 inches (76 mm) from this position.

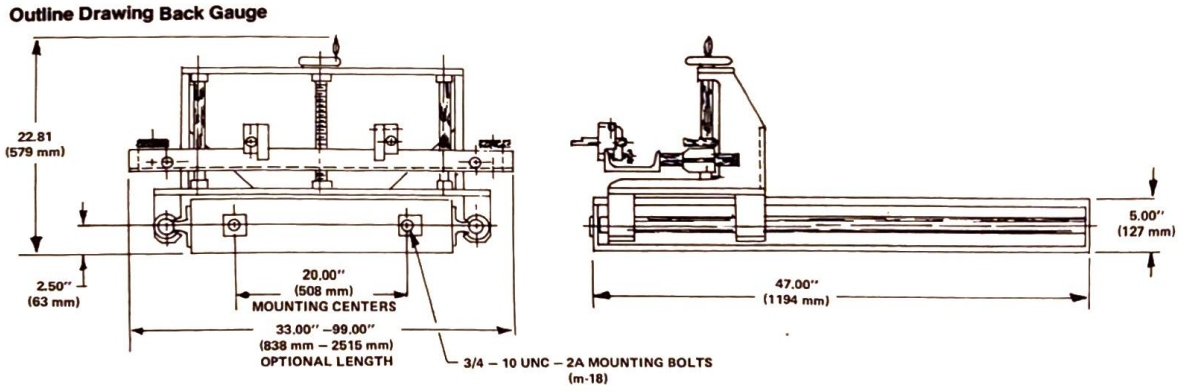


Figure 2-8

Therefore, the two (2) 3/4-10 (m 18) tapped holes should be located 11 3/4-inch (298 mm) down from the top of the average die. Generally, this locates the tapped holes 2 inches (51 mm) to 4 inches (102 mm) below the top of the press brake bed (see Figure 2-9). As a general rule the top surface of the cover plates should be flush with the top surface of the brake bed.

Locate, drill, and tap two (2) 3/4-10 UNC-2B (m 18) holes in the bed. Center these two holes between the side frames on 20.00-inch (508 mm) centers. Recommendation: Drill one (1) hole, snug up, then use 3/4-inch transfer punch to locate second hole.

Remove the two top covers, operating the carriage by hand to gain access to the cover retaining screws.

Installation Procedure

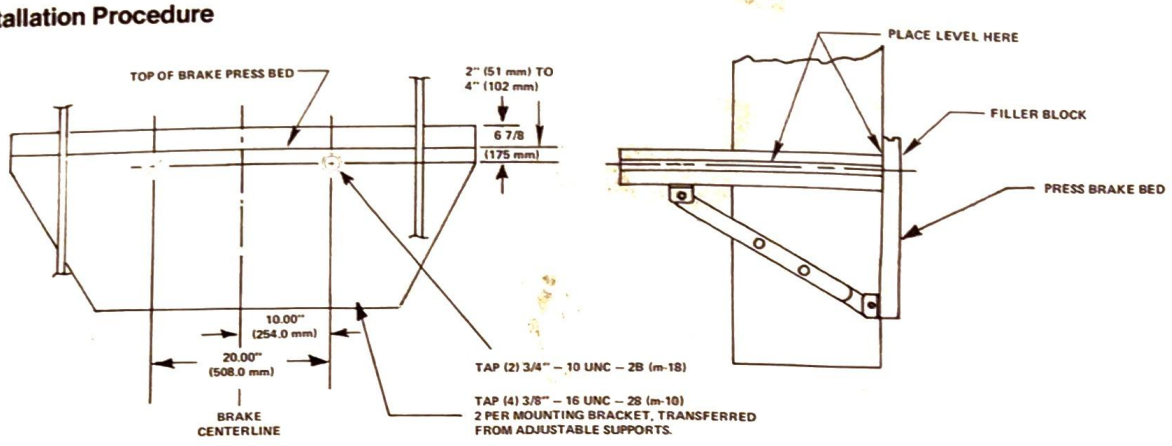

TOP OF BRAKE PRESS BED
2" (51 mm) TO 4" (102 mm)
6 7/8 (175 mm)
PLACE LEVEL HERE
FILLER BLOCK
PRESS BRAKE BED
10.00" (254.0 mm)
20.00" (508.0 mm)
BRAKE CENTERLINE
TAP (2) 3/4" – 10 UNC – 2B (m-18)
TAP (4) 3/8" – 16 UNC – 2B (m-10) 2 PER MOUNTING BRACKET, TRANSFERRED FROM ADJUSTABLE SUPPORTS.

Figure 2-9

Mount the back gauge mechanism to the brake bed using the two (2) 3/4-10 (m 18) bolts, spherical washers, and lock washers provided. Loosely insert the two (2) 3/4-inch (m 18) hex head bolts, as shown in Figure 2-10. Support the rear portion of the back gauge mechanism with a jack stand.

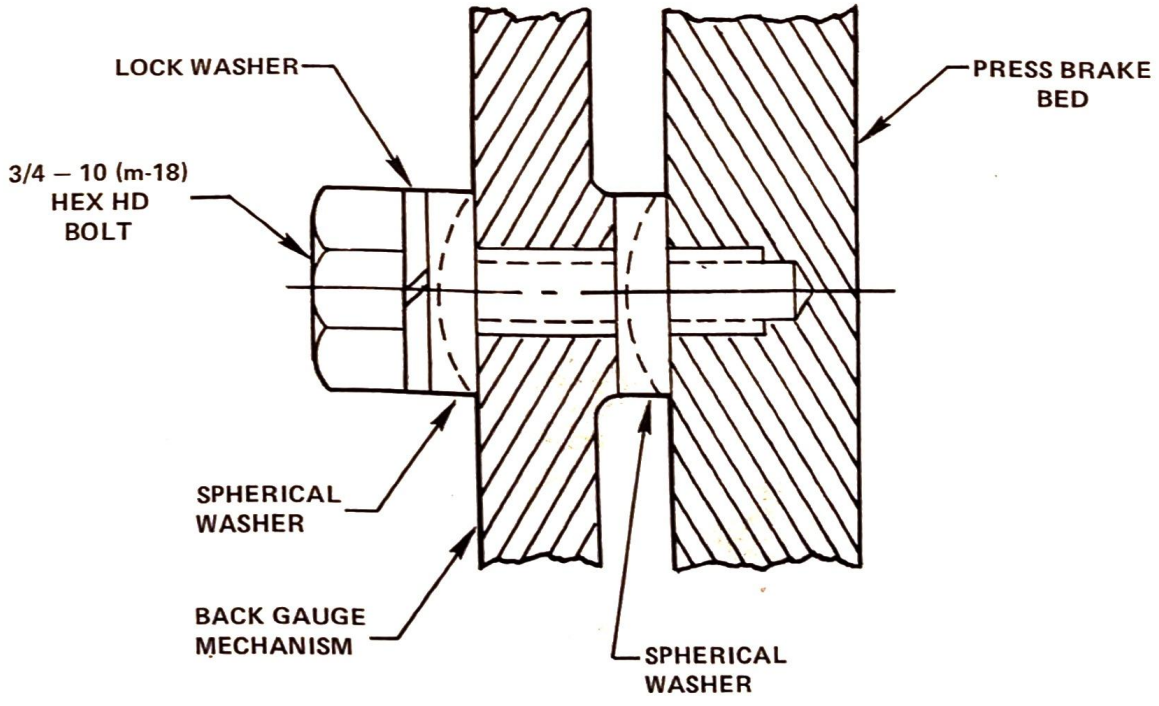


Figure 2-10

Using the jack stand, level the mechanism by placing a level on the 1 1/4-inch slide bearing rails perpendicular to the press brake bed. Level the other plane by placing the

level on the top surface of the casting parallel to and near the press brake bed. After achieving a level condition tighten the two (2) 3/4-inch (m 18) hex head bolts.

If there is no pump support shelf or obstructions in the lower portion of the press brake bed, assemble the two angle brackets and the three-piece extendable support legs to the back gauge mechanism, as shown in Figure 2-9.

Extend the support legs so that the angle bracket which mounts to the press brake bed is located as low as possible on the inside face of the press brake bed, as shown in Figure 2-9.

Hold the support legs in place; mark and spot the location of the two (2) 3/8-16 (m 10) tapped holes for each leg. Insure that the support legs are parallel to the slide bearing rail before transferring the location of the 3/8-16 (m 10) hole to the press brake bed. Drill and tap the four (4) 3/8-16 UNC-20 (m 10) in the bed.

Mount the bottom angle bracket to the bed and tighten the two (2) 3/8-inch (m 10) bolts on each bracket without disassembling the support legs. Now proceed to tighten the six (6) 3/8-inch nuts and bolts on each leg.

Remove the jack stand and recheck the level in both planes. Extend or shorten the support legs as required to achieve a level condition.

In cases where there are obstructions and a pump support shelf is available, the center section of the extendable support leg is not used. Assemble the two angle brackets and the two-piece extendable support legs to the back gauge mechanism. Proceed as above except locate, transfer, drill, and tap the two (2) 3/8-16 UNC-2B (m 10) per leg into the shelf as shown in Figure 2-11a.

2.4 ASSEMBLY OF GAUGE SUBASSEMBLIES

2.4.1 Assembling the Gauge Bar to the Carriage

The gauge bar is attached to the carriage on the two horizontal mounting shafts using a tapered washer, lockwasher, and nut (see Figure 2-12). The unit as received will have the washers and nut on the shafts.

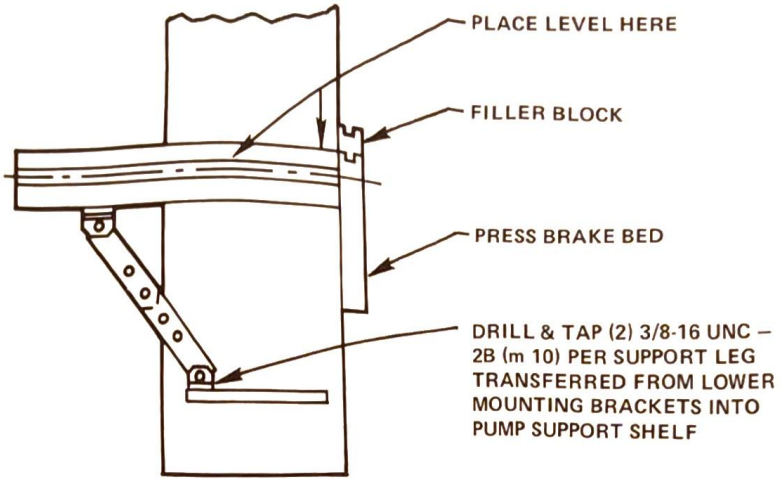

PLACE LEVEL HERE
FILLER BLOCK
PRESS BRAKE BED
DRILL & TAP (2) 3/8-16 UNC – 2B (m 10) PER SUPPORT LEG TRANSFERRED FROM LOWER MOUNTING BRACKETS INTO PUMP SUPPORT SHELF

Figure 2-11a

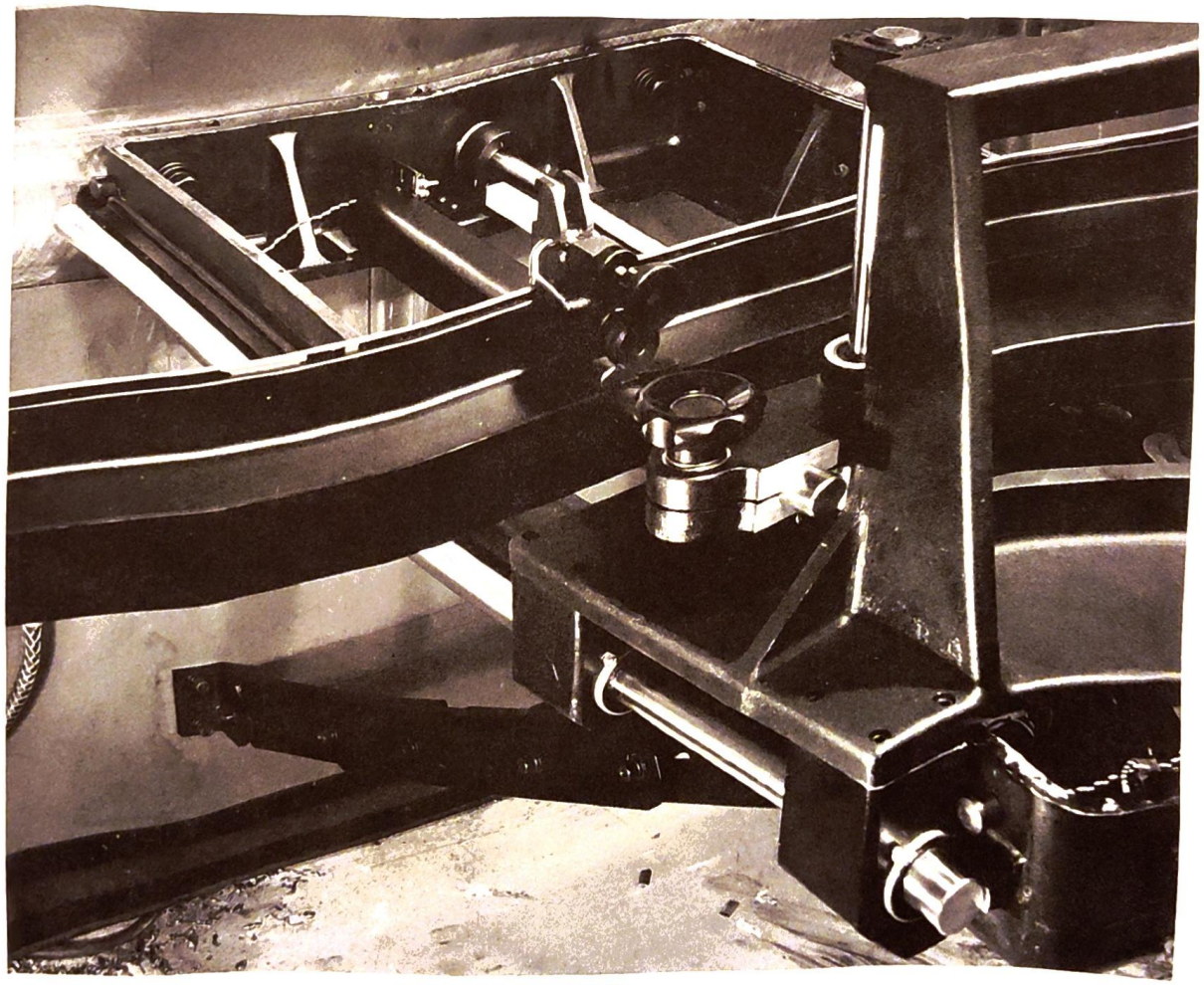


Figure 2-11b

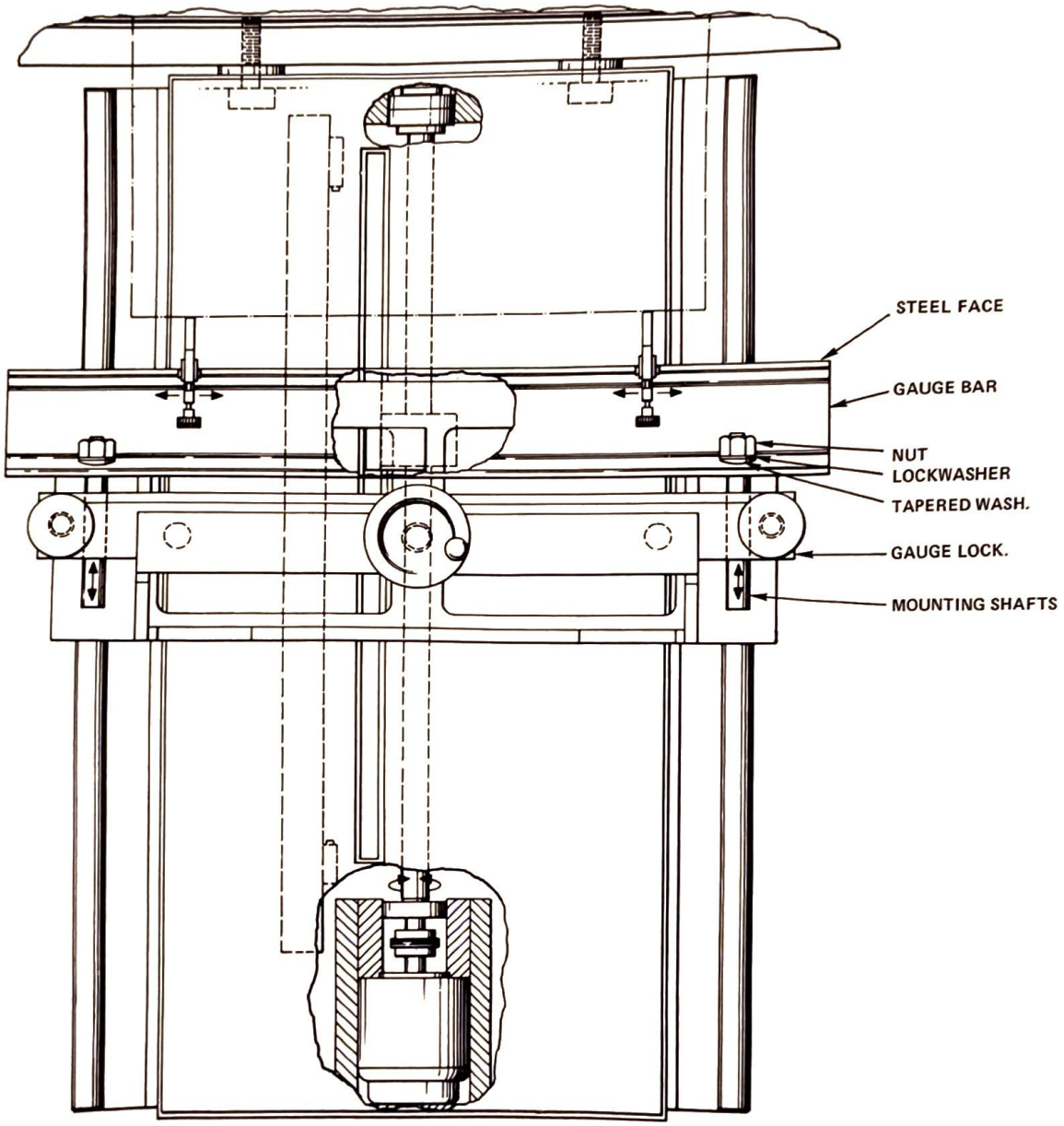


Figure 2-12. Gauge Bar Assembled to Upper Carriage

The gauge bar is mounted with the steel face towards the ram of the press brake. The gauge bar surface should be mounted flush against the machined shoulders of the mounting shafts. The tapered washer is installed with the thick side up. The nuts should be tightened until the split lockwasher is flat.

After the assembly is complete the gauge bar lock knobs should be loosened and the assembly moved as far as possible to the rear of the carriage and the knobs retightened before attempting a calibration procedure.

2.4.2 Assembling the Gauge Stops to the Gauge Bar

The gauge stop assemblies (shown in Figure 2-13) are made to slip over the steel face of the gauge bar. When the lock screw is loose, the assembly should move freely left and right across the bar for adjustment to the size stock to be used.

The in-out fine adjustment and the vertical set screw adjustment are used during the calibration procedure, see Section 3.2.

During initial assembly the vertical screw should require no adjustment. The in-out fine adjust should be set so the gauge stop is retracted towards the rear of the back gauge without losing the engagement between the stop and the adjusting screw.

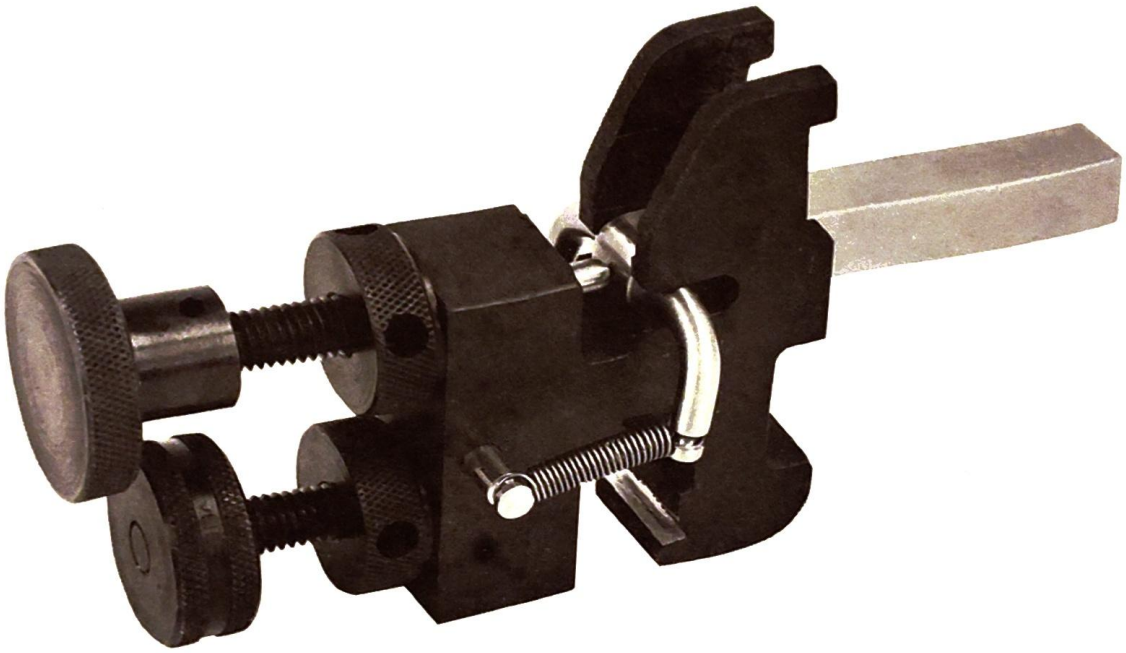


Figure 2-13. Gauge Stop Assembly

3. OPERATING INSTRUCTIONS

3.1 EXPLANATION OF THE DIGITAL CONTROLLER

3.1.1 Power-up States of the Back Gauge

The Back Gauge System is designed to have two partially OFF states as well as a fully ON and a fully OFF state.

STATE 1 – The Back Gauge System is *fully ON* when:

1. The AC cord from the controller is plugged in.
2. The key switch on the back of the controller is at ON (see Figure 3-1).
3. The feeder cord from the controller is plugged into the servoamplifier.
4. The pushbutton at the rear of the gauge is ON (see Figure 3-1).

STATE 2 – When pushbutton is set to OFF the electromechanical portion of the back gauge is turned off, leaving the controller electronics unaffected.

> CAUTION: This pushbutton should always be OFF when the Back Gauge System is being serviced.

STATE 3 – The entire front panel of the controller, plus the motor drive and the depth outputs are electrically off whenever the key switch of the controller is OFF.

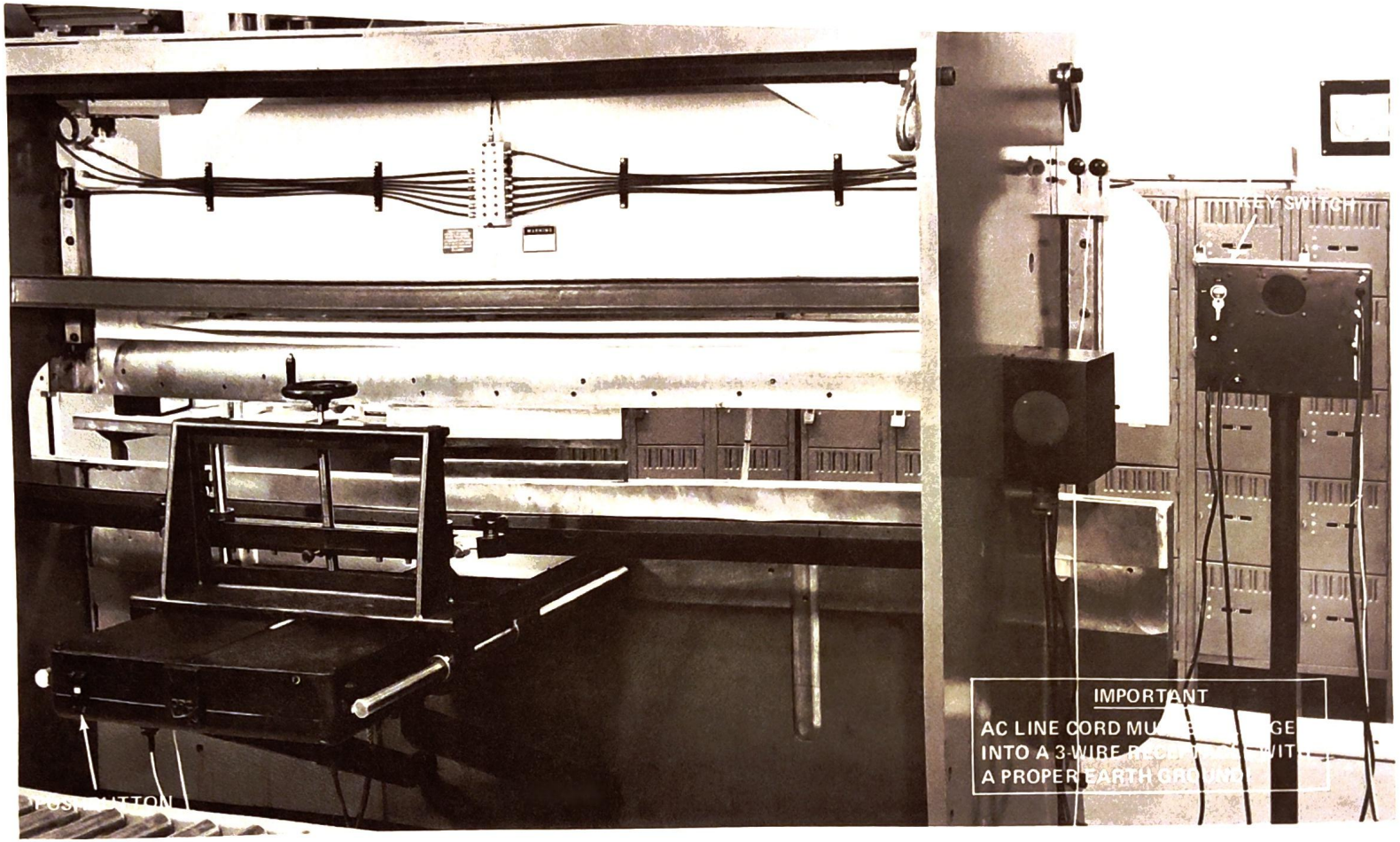


Figure 3-1. Location of Key Switch and Push Button

STATE 4 – The Back Gauge System is *fully OFF* if AC power is not supplied to the controller. This state is different from the partially off states (2 and 3) because in this state the controller loses track of the mechanical position of the back gauge. In *all other states* the controller continuously monitors the position of the back gauge. The cooling fan will run continually as long as the AC power line is plugged in.

Note that in each of the four ON/OFF states of the back gauge all data which had previously been entered and accepted by the controller will be maintained in the electronic memory of the controller.

3.1.2 Position Information

The back gauge position information is displayed and entered in either English or metric units. The system desired for the controller is selected by setting the IN/MM selector switch (Figure 3-2) at the top right corner of the front panel.

Figure 3-2. IN/MM Switch

If the selector switch is set to "IN" then the DIMENSION will read xx.xxx inches, the BEND ALLOWANCE will read .xxx inch, and all data entered is understood to be in inches.

If the selector switch is set to "MM" then the DIMENSION will read xxx.xx mm, the BEND ALLOWANCE will read x.xx mm and all data entered is understood to be in millimeters.

Instant conversion of the displayed data from one set of units to the other can be effected by changing the IN/MM selector switch.

3.1.3 Numeric Program Data

The lighted display area on the front panel (see Figure 3-3) shows the numeric program data that the operator

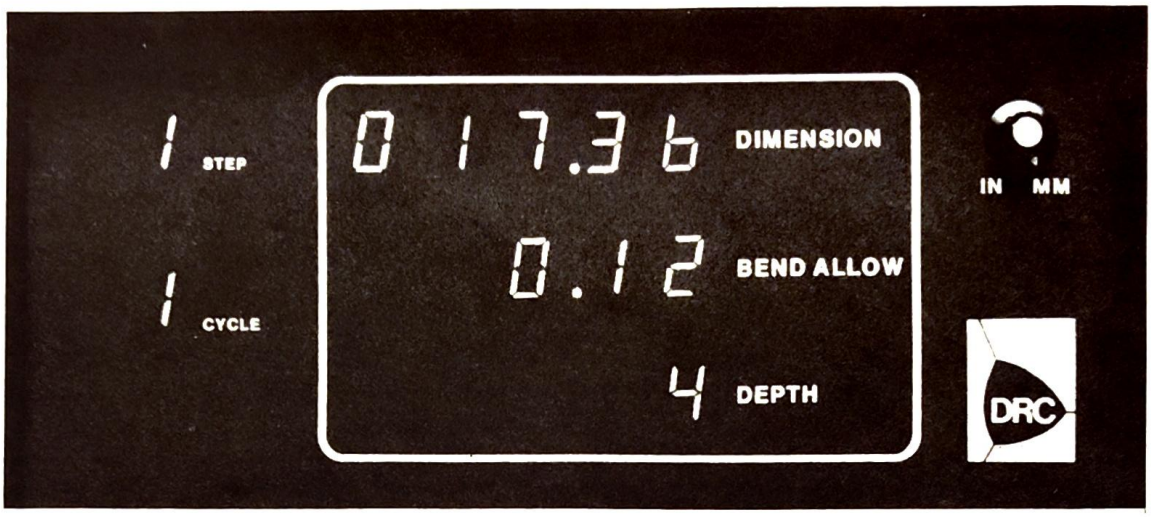


Figure 3-3

has entered. Data is displayed whenever the key switch is ON; nothing is displayed if either the key switch is OFF or if AC power is not supplied to the controller.

The program data is displayed in five sections:

1. Step – a number from 1 through 9 indicating the program step being displayed.
2. Dimension – the distance to which the back gauge will move (as measured from the die center).

   An all zero dimension is interpreted as an indication that no motion is required.
3. Bend Allowance – one number which will be subtracted from each of the nine dimensions of the program to determine the back gauge position. This number allows for the radius of the bend and thickness of stock being formed.
4. Cycle – A number from 0 through 9 indicating the number of times that a step is to be performed during automatic sequencing of the back gauge by the controller.

   A zero indicates that the step should not be performed.
5. Depth – A number from 0 through 9 indicating which electrical switch will control the depth of the ram stroke. To make use of this data the press brake must be equipped with a depth mechanism that is properly interfaced to this depth output signal.

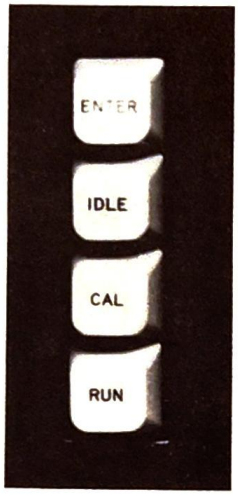


Figure 3-4

3.1.4 Modes

The four pushbutton keys ENTER, IDLE, CAL, and RUN, shown in Figure 3-4, allow the operator to select a mode for the controller. The actual mode of the controller is indicated by the lighted condition of one of the mode keys.

CALIBRATE drives the back gauge temporarily to the rear then to the point 4 inches away from the ram. The controller holds the gauge at 4 inches so the operator can check and, if need be, adjust the tool-to-finger distance.

> CAUTION: The operator should not attempt any of the mechanical operations of the calibrate mode before entering the CALIBRATE mode which allows the gauge to complete its travel.

ENTER allows entry, modification, storage, recall, and clearing of data in the controller without affecting the position of the back plane.

IDLE allows entry and modification of the data in the controller as well as a dimension-by-dimension positioning of the back gauge upon operator command.

RUN automatically positions the back gauge to the proper dimension in the program sequence after each actuation of the ram.

3.1.5 Data Entry

The basic functions of the keyboard are data entry and data manipulation. The five pushbutton switches STEP, DIM, CYCLE, DEPTH, and BEND ALLOW, shown in Figure 3-5, correspond to the five sections of the front panel display and enable the operator to indicate what data is being entered. Since data entry and data modification can only occur in the ENTER or the IDLE mode, these five keys are only active in the ENTER and IDLE modes. When an operator depresses one of these five keys in the ENTER or IDLE mode, the key that was depressed is illuminated. Data keyed in while one of these five keys is lighted is entered into the section indicated. This applies for the ten NUMERIC keys (Figure 3-6) as well as the DECIMAL POINT key and the CLEAR ENTRY key.

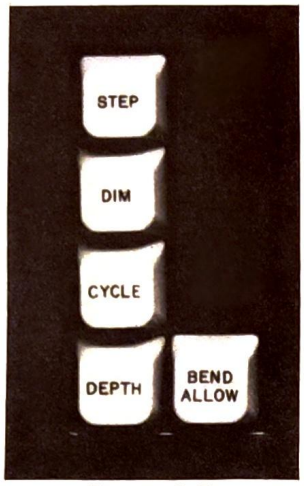


Figure 3-5

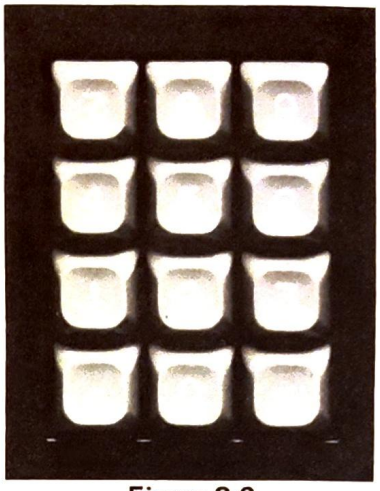


Figure 3-6

The PLUS and MINUS keys (Figure 3-7) allow the operator to add or subtract numbers from the DIMENSION and BEND ALLOWANCE sections for easy correction of the data in the ENTER and IDLE modes.

The STORE, RECALL, and CLEAR functions (Figure 3-8) are only active in the ENTER mode. These three keys manipulate whole blocks of data within ten areas of data memory:

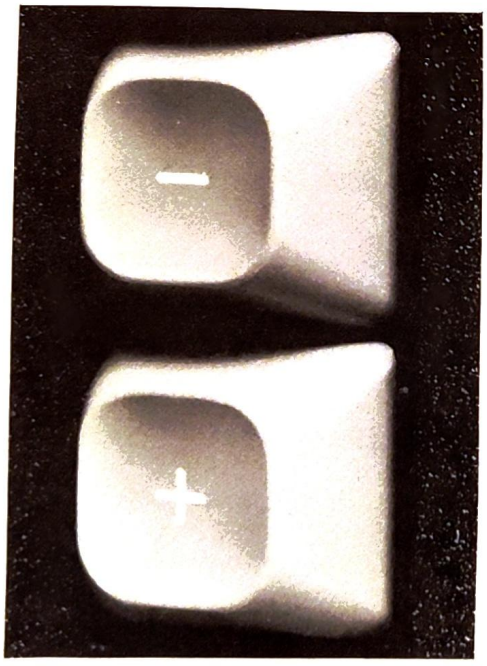


Figure 3-7. + — Keys

1. active area
2. storage area 1
3. storage area 2
4. storage area 3
5. storage area 4
6. storage area 5
7. storage area 6
8. storage area 7
9. storage area 8
10. storage area 9.

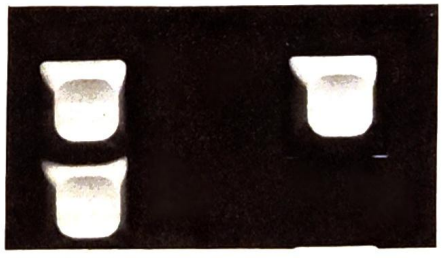


Figure 3-8

The data, consisting of the nine steps, each with its own DIMENSION, CYCLE, and DEPTH information, is originally entered into the active area of memory via the keyboard.

STORE (plus a NUMBER switch depression) takes all the data in the active area of memory and copies it into the designated (i.e., as indicated by the number) storage area.

RECALL (plus a NUMBER switch depression) copies all the data from the indicated (i.e., NUMBER) storage area into the active area.

CLEAR sets DIM = 0, BEND ALLOW = 0, DEPTH = 0, and CYCLE - 1 in all nine steps of the active area of the program memory space.

The SEQUENCE key (Figure 3-9) advances the program to the next step.

Figure 3-9

If the back gauge is moving, depressing the STOP key instantly stops the motion of the back gauge and puts the controller into the ENTER mode. If the back gauge is not moving and the controller is not in ENTER then STOP will have no effect.

If the controller is in ENTER and the CYCLE key is lighted, STOP will enter a pause code into the current program step creating a 2- to 3-second pause before performing the next program step when in RUN mode. This pause code will be cleared when the cycle's information is cleared.

3.1.6 Example of DRC Back Gauge Programming

Programming of the DRC Back Gauge can be best understood with the aid of an example. Assume that precut pieces of 1/4-inch stock are to receive 90-degree bends along the four dotted lines shown in Figure 3-10. The programming might proceed as follows:

1. Put the proper tool and die into the press brake.
2. Make sure that the controller is fully on (see Section 3.1.1).
3. Set the "IN/MM" selector switch to inches.
4. Check that the ram is up and nothing is obstructing the motion of the back gauge before pressing the CALIBRATE button.

5. Press the CALIBRATE button and observe the gauge to move first to 27.000 inches then reverse and go to 4.000 inches where it comes to rest with the CALIBRATE button lighted.

6. With the back gauge at 4 inches put the calibration bar in the tool, then, lower the ram and mechanically adjust the fingers on the gauge bar to exactly touch the precision machined end of the 4-inch calibration bar (see calibration procedure, Section 3.2).

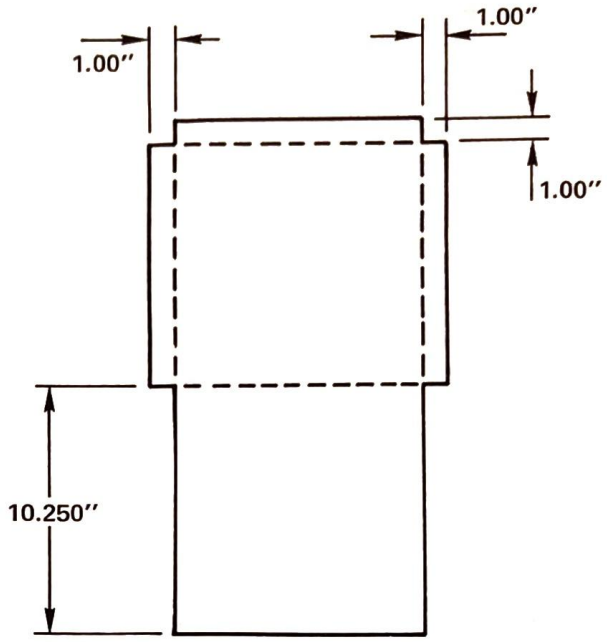


Figure 3-10

7. Lift the ram and remove the calibration bar.

8. Press the ENTER button and note that it lights up (the CALIBRATION light goes out).

9. Press the CLEAR button. The display panel will now show:

1 step
1 cycle

```
00.000 DIMENSION
  .000 BEND ALLOW
    0 DEPTH
```

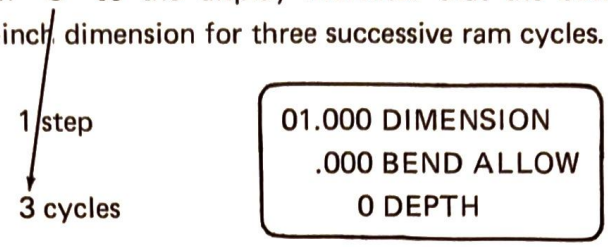
10. To program the three repetitions of the 1-inch bend shown in Figure 3-10 first hit the "DIM" button, then the "1" button. The display will now read:

1 step
1 cycle

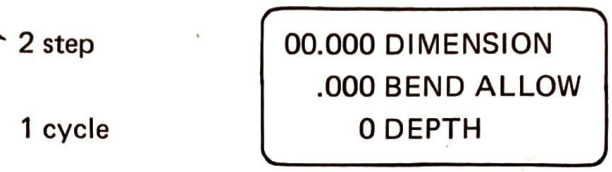
```
01.000 DIMENSION
  .000 BEND ALLOW
    0 DEPTH
```

Note that the trailing zeros in the 1.000-inch dimension do not have to be keyed in.

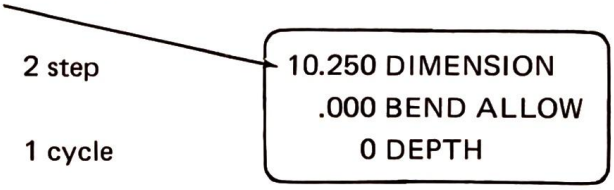
Hit "CYCLE" then "3" so the display indicates that the back gauge will be positioned at the 1-inch dimension for three successive ram cycles.



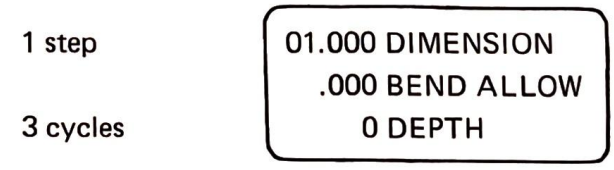
11. To program the remaining bend of Figure 3-10 we first press the "STEP" button then "2" so the display shows:



Now press "DIM", then "1", then "0", then "." (i.e., decimal point), then "2", then "5" to program one cycle of the 10.250-inch bend.

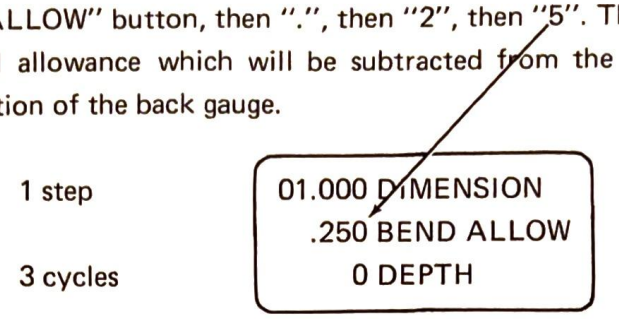


12. Push the IDLE button. It will light up and the display will indicate the previously entered information of Step 1.



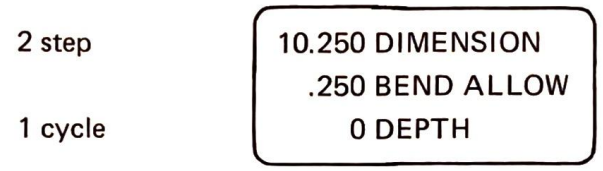
13. Check that the ram is up and unobstructed then hit the SEQUENCE button. The back gauge will move from its 4-inch position to 1.000-inch. Insert a piece of stock against the gauge bar fingers and operate the ram. Remove the stock and measure the bent piece. If the bend is not correct, it may be because the radius of curvature of the 1/4-inch stock was not considered. This can be corrected by keying in a BEND ALLOWANCE.

14. Press the "BEND ALLOW" button, then ".", then "2", then "5". The display will now show a bend allowance which will be subtracted from the dimension to determine the position of the back gauge.

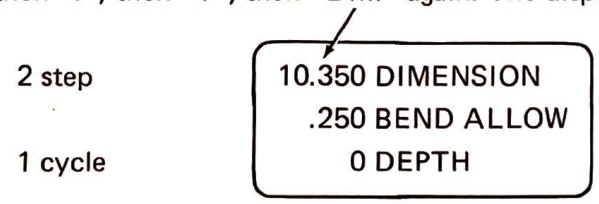


15. Pressing the SEQUENCE button will now move the back gauge to the redefined position of step 1 (i.e., 1.000 – .250 = 0.750 inch). Bend another trial piece and measure it.

16. If this trial bend is correct, press SEQUENCE to move the back gauge to the dimension in step 2 (i.e., 10.250 – .250 = 10.000 inches) and bend a trial piece.



17. If this bend measures slightly short, the dimension can be modified by pressing "DIM", then "+", then ".", then "1", then "DIM" again. The display will show



18. Pressing SEQUENCE will move the back gauge to the modified position where another trial bend can be made. If this is a good bend the program is finalized and ready to run. The program is run by pressing "STEP" then "1", and then the RUN button.

19. Check that the ram is up and nothing is obstructing the back gauge, then press the SEQUENCE button.

    Operation will proceed automatically as follows. The back gauge will move to .750 inch (i.e., 1.000 – .250 = .750 inch) and will stay there through three operations of the ram (i.e., CYCLE = 3 for step 1). The back gauge will then move to 10.1 inches (i.e., 10.325 inches – .250 inch) and stay there through one operation of the ram. When the ram returns to the top of its stroke the back gauge will move to .750 inch and stay there for the next three ram operations.

If we now wish to stop fabrication and resume later we might choose to turn the key switch to OFF and take the key out of the unit (see Section 3.1.1). This will inhibit anyone without a key to operate the unit from both running the back gauge and overwriting the program. If we later reinsert the key and switch it to ON the unit will display STEP 1 of our example program with the ENTER key lighted. If we now press RUN and SEQUENCE we can resume automatic operation at step 1.

If we wish to reprogram the back gauge for some other operation but do not want to lose the example program we could preserve the program.

1. Press the ENTER button.
2. Press STORE then "1" – this stores the program in storage area 1 (see Section 3.1.5).
3. Press CLEAR to clear the program entry area.
4. At this point we can enter new program data without affecting the example program stored in storage area 1.
5. If we want to rerun the example program at some later date:
   a. Press the ENTER button.
   b. Press "RECALL", then "1".
   c. Check the validity of the program and then run it by pressing RUN and the SEQUENCE.

If we now wish to include the two-step example program of Figure 3-10 as a part of another program we might choose to "chain" it with a program that is stored in storage area 2. Chaining programs is done by using the automatic recall feature (i.e., a 9 in the highest digit of the dimension is interpreted as an automatic recall code. The storage area is determined by the number in the CYCLE display).

1. Press ENTER, then "RECALL", then "1" to bring out the program of Figure 3-10.
2. Press "STEP", "3".
3. Press "DIM", "9", "0" (if in millimeters, press DIM, "9", "0", "0").

4. Press "CYCLES", "2". The program in storage area 1 now has an automatic RECALL "2" code at its end. So, after performing the two steps of the example program it will continue with whatever is in storage area 2.

5. Press STORE, "1" to store the modified program back in storage area 1.

6. Now, press RECALL, "2" to bring out the other program that is to be linked together.

7. Press STEP, "9". (Assuming the program stored in area 2 has 8 steps.)

8. Press DIM, "9", "0".

9. Press CYCLE, "1".

10. Press STORE, "2".

The two programs are "chained" together as one longer program because the program in storage area 1 has an automatic RECALL "2" at its end and the program in storage area 2 has automatic RECALL "1" at the end of it. Hence, the two programs will run as one longer (i.e., chained) program with 10 steps (2 in the program stored in area 1 plus the 8 in the program stored in area 2).

CAUTION: Keys should be pressed firmly and not in rapid succession.

3.2 REFERENCING THE FORMING TOOL

1. Clear the area behind the press brake of all material and personnel.

2. Remove both gauge stop assemblies from the gauge bar (see Figure 3-11).

3. Install the plug of the controller into a 110 VAC outlet and turn key switch, located on the back panel of the controller, to the "ON" position. All the digits will now read "0" and the calibration button will be flashing.

4. Depress the calibration (CAL) button (see Figure 3-12). The gauge bar will move to the rear of the back gauge, stop, change direction, and move forward until it stops at the calibration position. The calibration button will stop flashing and the dimension digits will read 04.000. The back gauge is now ready to calibrate mechanically.

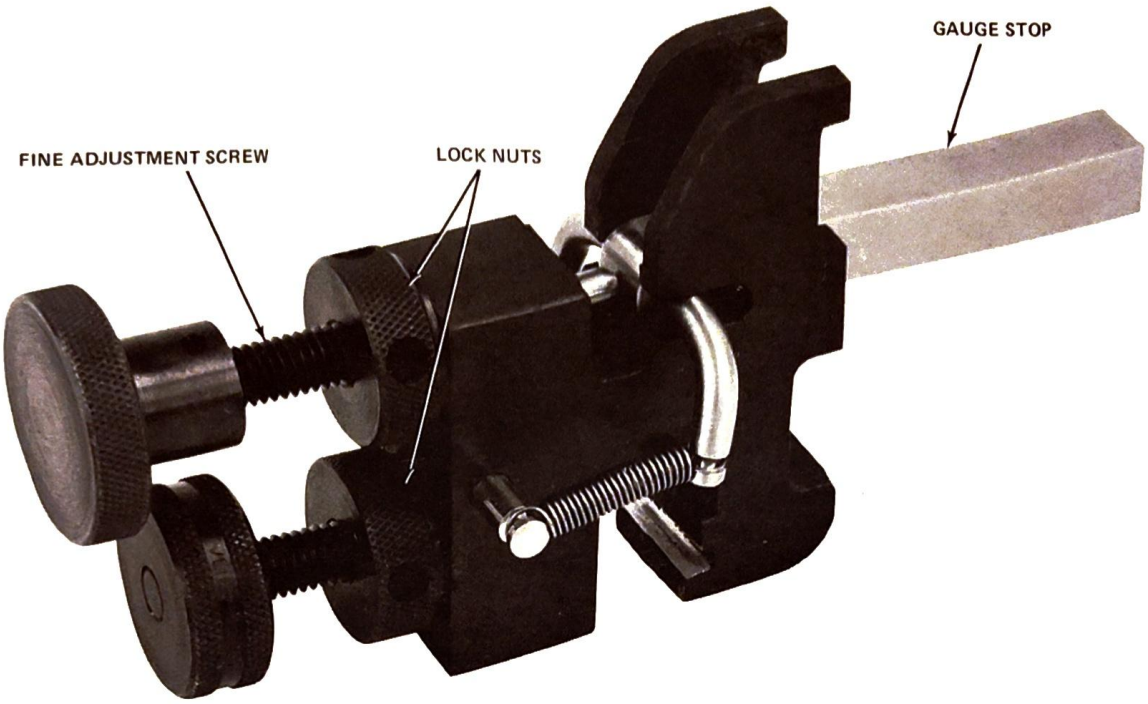


Figure 3-11. Gauge Stop Assembly

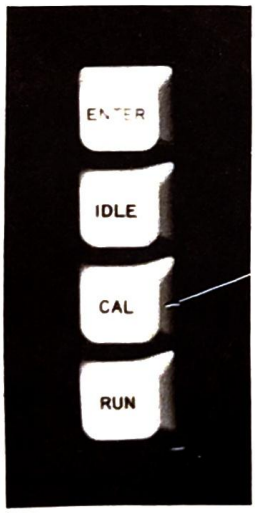


Figure 3-12

5. Two self-centering gauge blocks (see Figure 3-13) are supplied with each back gauge. These are to be laid on the die being used at a position near the outer longitudinal limits of the piece being formed. Lower the ram with punch installed by hand cranking or by using the jog button if machine is so equipped. The punch will enter the 90° notch and will center the gauge blocks in relation to the center line of the punch. Stop moving the punch as soon as the gauge blocks are snug.

6. Install both gauge stops on the gauge bar. Slide them to a position on the bar so that the stops are in front of the gauge block surface, and lock them in place.

7. Loosen the locking mechanism on the vertical adjusting wheel screw (see Figure 3-14) and raise or lower the gauge bar to the correct height for the die being used. Lock the mechanism.

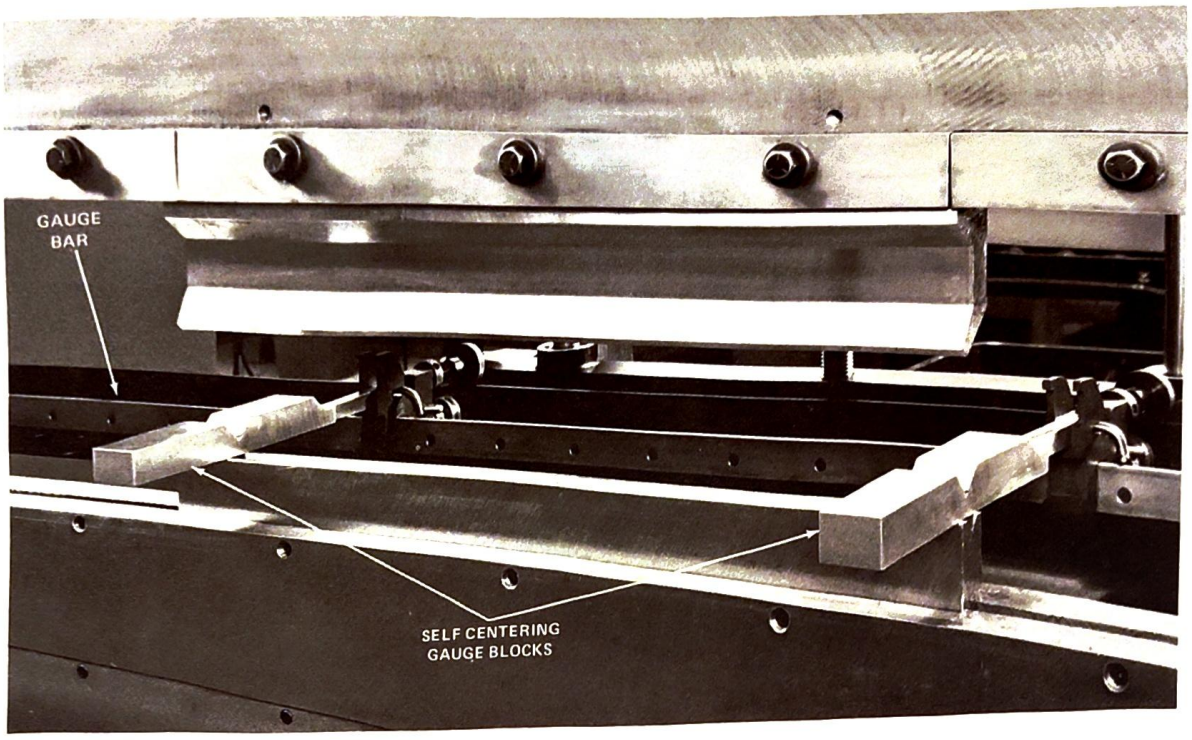


Figure 3-13. Self Centering Gauge Blocks

8. Loosen the two locking screws on the crossbar (see Figure 3-14) and slide the gauge bar forward until the ends of the gauge stops are approximately 1/16 to 1/8 inch away from the gauge blocks. Lock the two locking screws.

9. Loosen the knurled lock nuts on the fine adjusting screws (see Figure 3-11) on both stop assemblies and adjust the forward portion so that they touch the ground surfaces of both gauge blocks. Tighten lock nuts.

10. Raise punch; remove gauge blocks. The back gauge stops are now referenced for that particular punch.

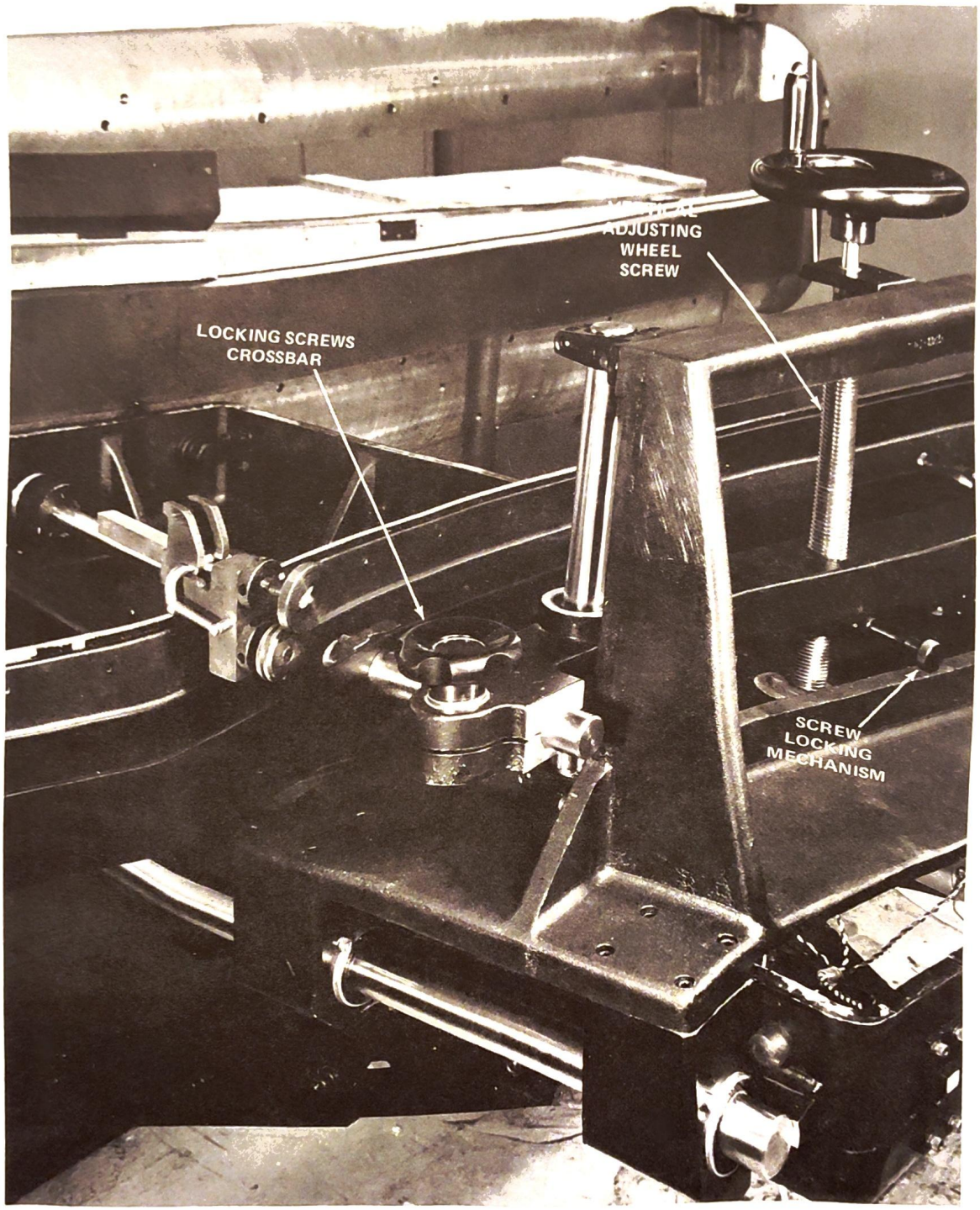

ADJUSTING
WHEEL
SCREW
LOCKING SCREWS
CROSSBAR
SCREW
LOCKING
MECHANISM

Figure 3-14

4. THEORY OF OPERATION

The back gauge system consists of three main elements: the controller, the servo unit, and the mechanical back gauge.

The controller is the operator interface and the system computer. As the name implies it is the control element for the rest of the system. Bend sequence data and dimensions are entered by the operator via the keyboard. This information is stored in memory in the controller, displayed back to the operator, and is used to automatically position the back gauge.

The servo unit is self contained with its own power supply and amplifier. It is typically mounted on the side of the press brake. It receives digital commands from the controller and processes them into analog drive signals to the DC servomotor to position the back gauge.

The mechanical back gauge is rigidly mounted to the press brake and houses the servo motor, the Rohlix linear actuator, and linear transducer for position feedback. A simplified block diagram of the total Back Gauge System is shown in Figure 4-1.

4.1 THE CONTROLLER

The controller is organized into three distinct operational elements which are each individually removable and replaceable in the field (see Service). Each is interconnected by a distribution card (mother board). See Figure 4-2 for an open view of the controller.

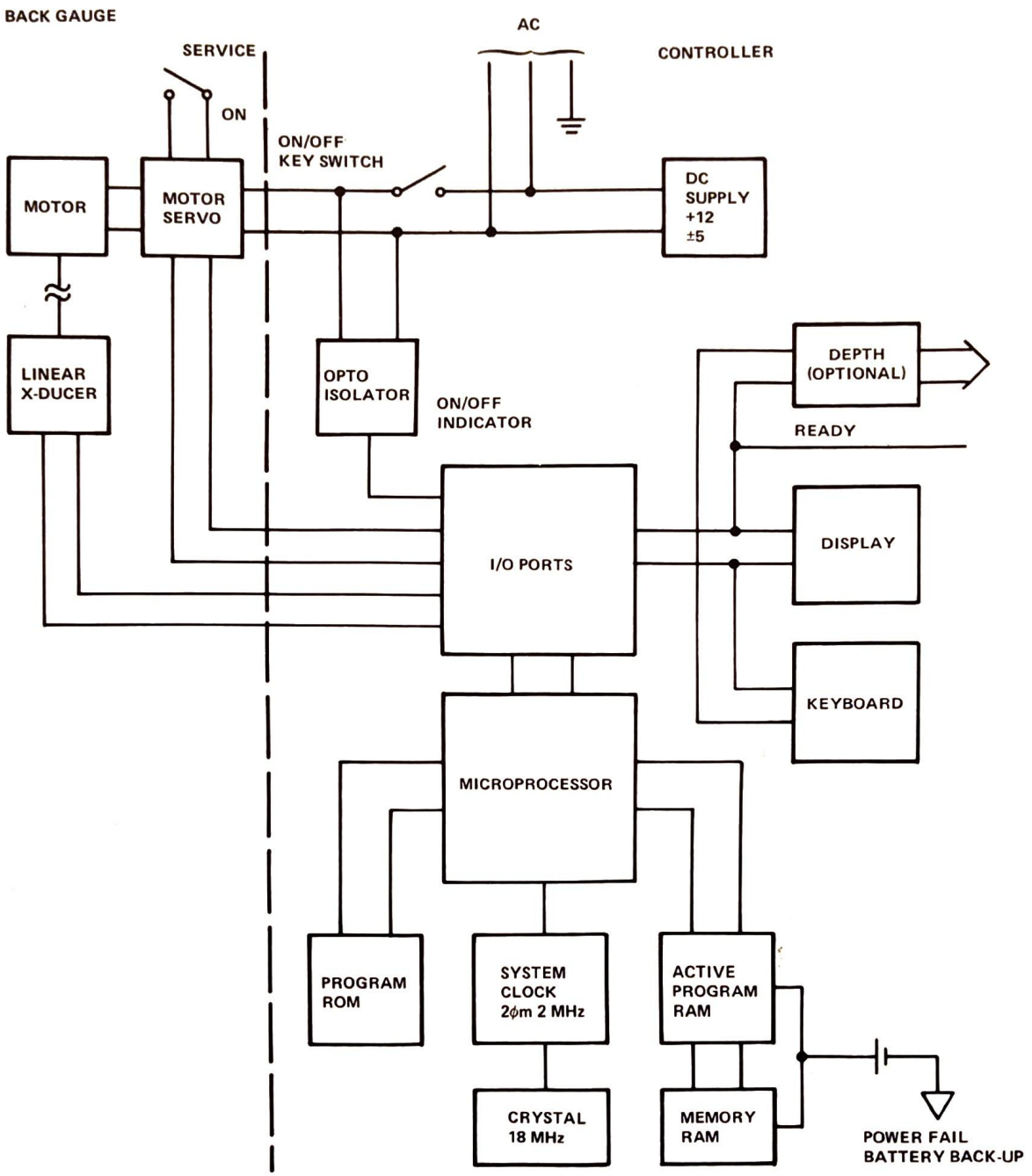


Figure 4-1. Back Gauge Block Diagram

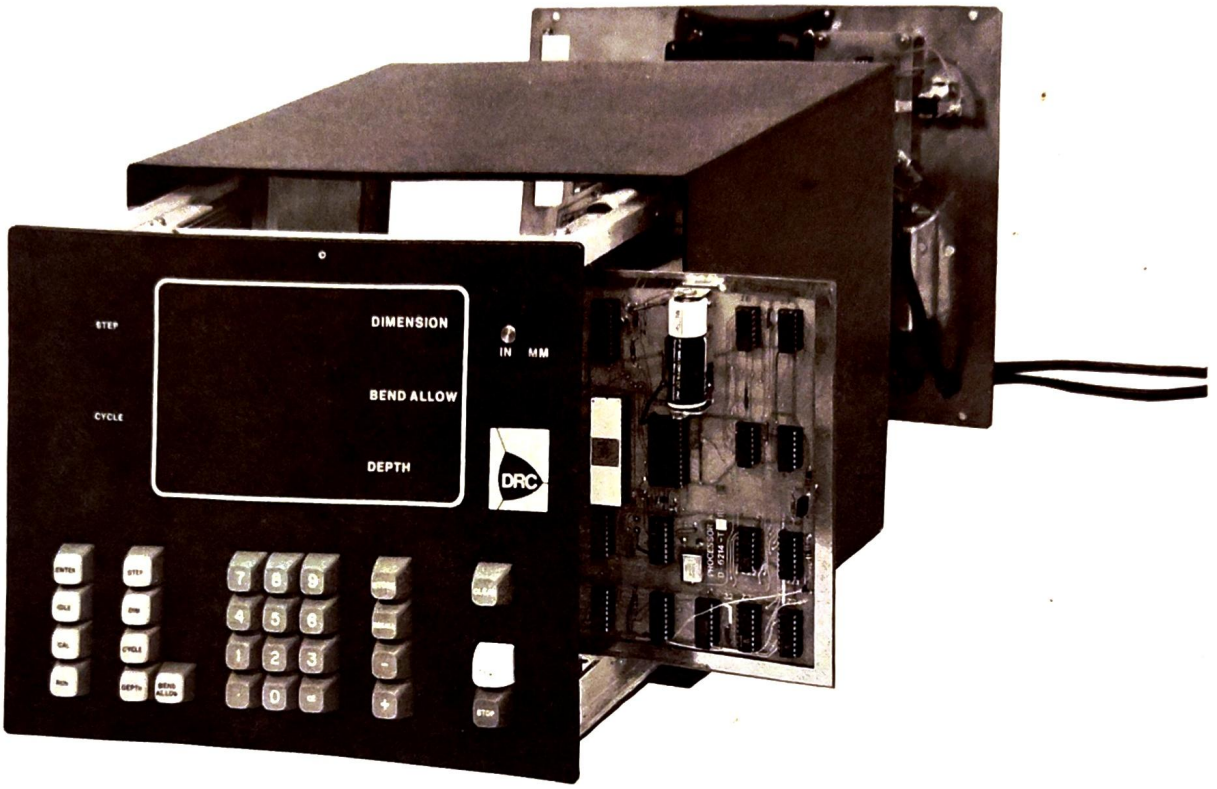


Figure 4-2. Open View of Controller

The three operational elements of the controller are the:

1. Power panel
2. Central Processor card
3. Keyboard and Display panel.

The operation of each will be discussed separately in detail illustrating its function in the overall system.

4.1.1 Power Panel

The power panel consists of the power supply, the ON/OFF power switch, and a power status card, and provides support for the cables that interconnect to the other parts of the system (see Figures 4-3 and 4-4).

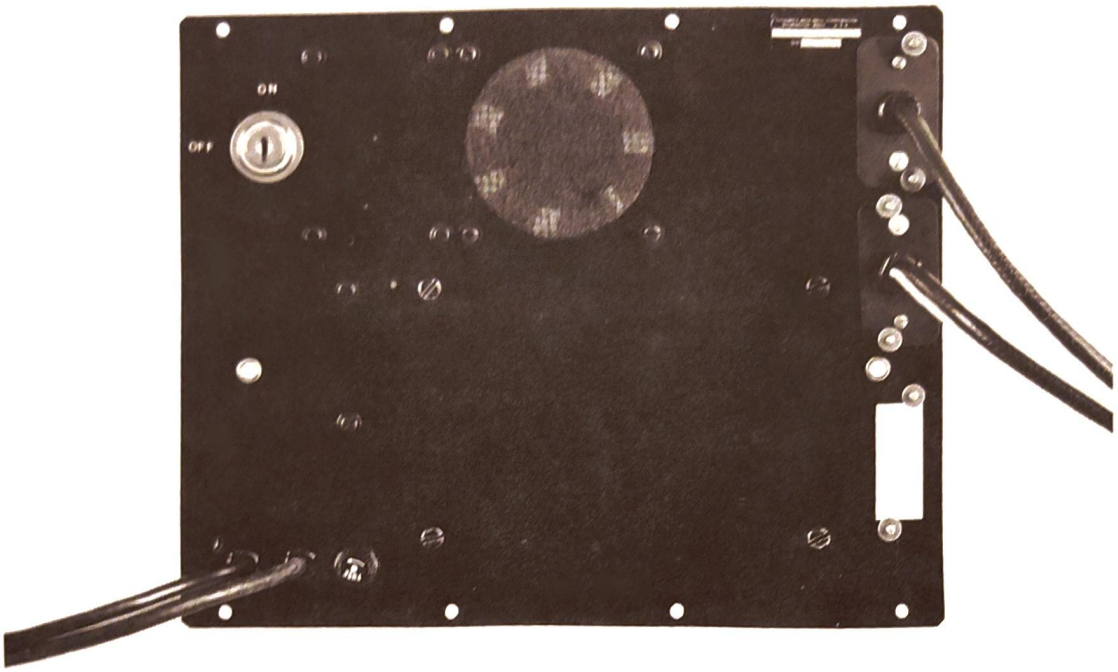


Figure 4-3. Back View of Controller Power Panel

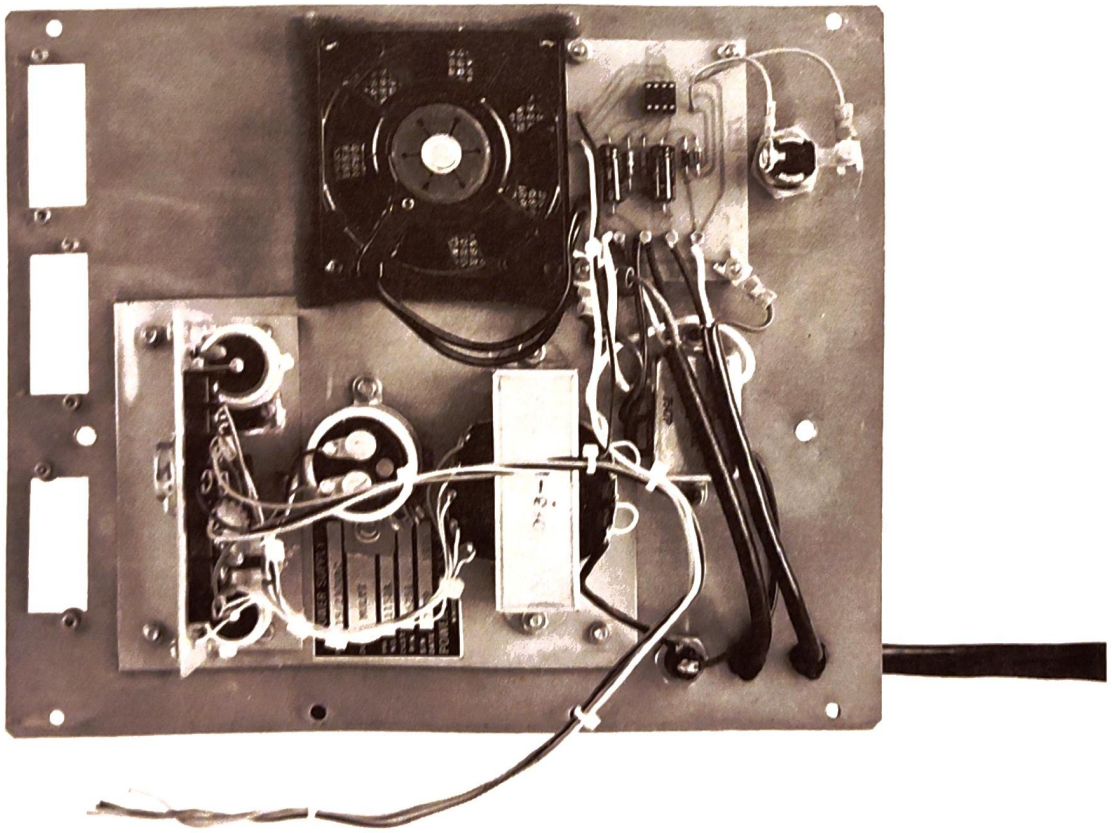


Figure 4-4. Inside View of Controller Power Panel

The power supply provides DC power to the central processor, keyboard, display, and the linear transducer in the mechanical assembly. The voltages developed are +12 and ±5. Each supply has short circuit current limit and overvoltage protection.

The ON/OFF power switch applies AC power to the servo unit, the central processor, and the linear transducer in the "ON" position. In the "OFF" position AC power is removed from the servo to eliminate any possibility of driving the back gauge. However, power is still applied internally to the central processor and the linear transducer. The back gauge position is being continually monitored by the central processor and should the back gauge position be changed either inadvertently or for service of the brake, operation may be resumed without the need for recalibration. The AC power also maintains the memory battery.

The power status card monitors the AC line voltage through a half-wave rectifier and filter which drives an opto-isolator. Thus the position of the ON/OFF switch is monitored by the isolator. This status is in turn used by the central processor as a signal to disable the keyboard and display in the "OFF" position. Should AC power go down momentarily for any reason for a period of time long enough to cause the power supply to reach marginal operation levels, this condition will be displayed to the operator through the keyboard. With such a power loss during normal operation, the system will disable any drive command to the servo and the calibrate key (CAL) on the keyboard will flash. If power should be lost overnight with the switch OFF, when the switch is turned ON the calibrate key will flash. Both situations require that the system be recalibrated prior to proceeding.

4.1.2 Central Processor Card

The central processor is a microcomputer whose character is established by three read only memories (ROM). Synchronization is established by a two phase clock operating at 2 mHz. The clock is stabilized because it is derived from a crystal oscillator operating at 18 mHz. The central processor card also contains support electronics for interfacing the various input/output functions (I/O), such as keyboard, display, servo commands, and transducer position feedback.

The programs that have been established in ROM are selected by the operator by depressing keys on the keyboard: to enter data, check bend dimensions, automatic program sequencing, and calibration. Specific keyboard and other functions will be discussed later.

The central processor is continually monitoring back plane position via the transducer feedback and generates commands to the servo, thus providing a closed loop control system.

Movement of the transducer is accumulated in an 8-bit up/down counter. Every 400 microseconds this counter is strobed, counts since the last strobe are added to or subtracted from the previous position and compared against the desired position, and the counter is zeroed. The difference is computed and a servo command is given in an 8-bit digital word indicating direction of motion and velocity.

When data is entered from the keyboard it is stored in electronic random access memory (RAM). Dimensional data may be entered in either inches or millimeters. The computer immediately calculates the opposite dimensional equivalent and stores both in memory. The RAM consists of two separate functional sections, active memory and stored memory.

Active memory contains the data which is being displayed. This data may be changed by keyboard entry and is the working memory. Back plane position is also stored in this memory.

Stored memory is selected by the STORE key on the front panel. The entire data from the active memory is transferred to one of nine storage locations selected from the keyboard. Data presently in the active memory is maintained. Data in the stored memory may be recalled to the active memory by depressing the RECALL key in the keyboard. Recalled data from storage replaces the existing active memory file but the stored memory remains intact.

Both active and stored memory are protected during power outages by a long life alkaline battery. This battery is 4.5 volts nominal. The memories will retain data to a 2-volt supply level. During normal operation the battery is held at voltage by a very slow trickle charge from the 5-volt supply. During power outage, data in memory is retained for at least 2 weeks.

The central processor card also provides an output signal which indicates that the back plane is stable at the last programmed position. This signal is buffered for external use by an opto-isolator.

An optional switch closure is provided to select up to nine different ram depths for bend angle control. The ram depths are programmable for each bend position. Switch closure may be made either to 110 VAC or 220 VAC relay excitation lines. This assumes mechanical switch closures can be provided that are set at each depth level desired. As the ram passes the switch corresponding to the programmed depth, the switch closure provided energizes external control circuitry to reverse the ram.

4.1.3 Keyboard and Display

The keyboard and display provide the operator's interface with the controller. The keyboard consists of 27 magnetically actuated key switches. The display is 0.63-inch seven-segment LED displays.

The keyboard contains all the key matrix decoding logic. Depressing any key will establish a unique 8-bit digital word that is read by the central processor. In addition, the keyboard also receives and decodes the position of the IN/MM switch and a single switch closure from the press which indicates that the ram is in the up position. The keyboard is arranged into four main modes, four submodes which are operational only in certain main modes, and support keys which are again operational only in certain submodes (see Figure 4-5).

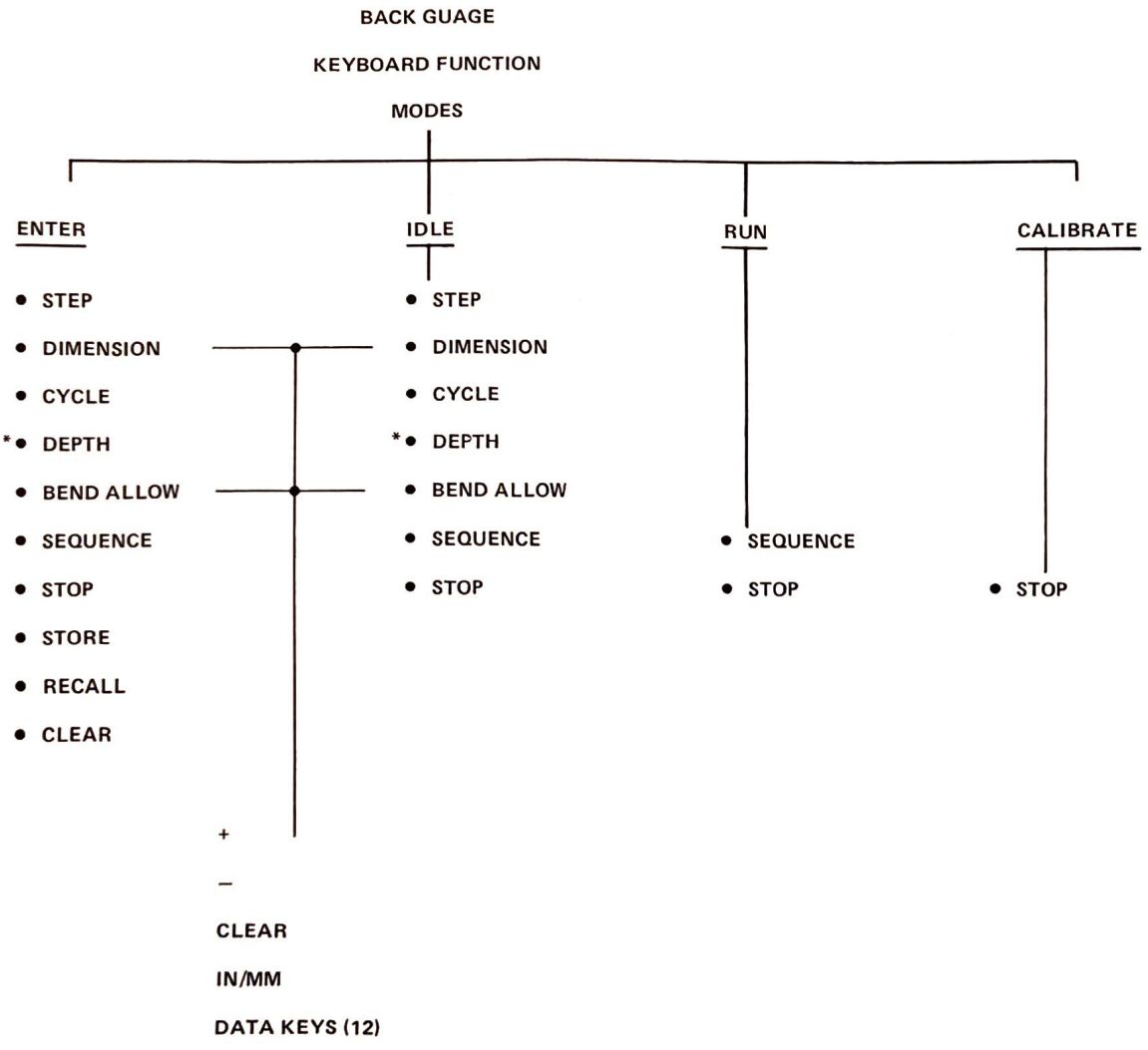


Figure 4-5. Back Gauge Keyboard Function

Operator feedback is established visually. Each of the main and submode keys light when depressed and remain lit as long as they are recognized by the central processor. The data entry is displayed as entered on the LED display next to the labeled function (see Figure 4-6). Changing the IN/MM switch displays the appropriate dimension.

Figure 4-6. Front View of Controller

If power goes down, the calibrate light will flash giving visual indication. If the ram is brought down prior to the back plane reaching the desired position or if the stop key is depressed during positioning, the drive stops and the controller returns to the ENTER mode. It is necessary for the ram to be fully up and the RAM UP switch closed or all commands to drive the back gauge will abort as above.

A brief explanation of the keyboard modes is given below.

4.1.4 Main Modes

Enter – Bend programs are entered in this mode. ENTER is the only mode in which programs may be stored or recalled from memory. The back gauge position cannot be driven in the ENTER modes.

Idle – Programs may be checked in the IDLE mode. The back gauge may be positioned to each dimension in the program by depressing the SEQUENCE key. Bends can be made and dimensions corrected as required.

Calibrate – The back gauge will automatically be driven to a predetermined mechanical position by first driving back to an optical reference on the linear transducer. If the calibrate (CAL) light is flashing, the keyboard is locked out and the Calibrate key must be depressed to resume normal operation.

Run – In the RUN mode the back gauge will automatically sequence through the active program. The automatic operation is initialized by depressing the SEQUENCE key and continued by cycling the ram.

4.1.5 Submodes

Step – Allows assignment of a number to each bend in the program sequence.

Dimension – Allows entry of the dimension for each bend referenced to the die center. Dimension "0" does not exist. A "0" in dimension indicates that step will be skipped.

Cycle – Represents the number of times any bend may be repeated. Setting cycle to zero in any step of the program will skip that step.

Bend Allowance – Allows entry of a physical constant related to material thickness and die shape. This dimension is automatically subtracted from the given dimension to give the actual position of the back gauge. (Note: Bend allowance cannot be greater than the dimension entered.)

Depth (optional) – Allows selection of any one of up to nine electrical switches with preset depth settings for synchronization with gauge position. Used only in conjunction with hydraulic brakes equipped with multiple depth setting switches.

4.1.6 Support Keys

Data Keys – Data keys include all numbers in addition to the decimal point and a clear entry (CE). CE zeros only the data in the selected submode. Data keys are operational only in ENTER and IDLE modes.

Clear – Clears or zeros all data and dimensions in all steps of the active program. CLEAR does not affect any stored program and is operational only in ENTER mode.

Store – Will place the entire active program in any one of nine selected bins of memory. STORE will erase any data previously in that bin but does not affect the active program. STORE is operational only in ENTER mode.

Recall – Will recall a program in a selected memory bin to the active memory. RECALL will not affect the stored program, but will erase the previous active program. RECALL is operational only in ENTER mode.

Minus – Will subtract the number entered from either Dimension or Bend Allowance and redisplay subtracted result when key of unit being adjusted is again depressed. This can be done in ENTER and IDLE modes.

Plus – Will add the number entered to either Dimension or Bend Allowance and redisplay added result when key of unit being adjusted is again depressed. This can be done in ENTER and IDLE modes.

Sequence – This key will advance the program to the next step. In ENTER the back plane does not move. In IDLE the back plane will position to the dimension of the next step. In RUN the SEQUENCE key must be depressed once to initiate automatic positioning.

Stop – During drive of the back gauge, it will disengage the motor drive and return the controller to the ENTER mode. This is operational in IDLE, CAL, and RUN modes. In the ENTER mode, STOP may be used to program a fixed delay of 3 seconds between any two steps of the program.

IN/MM – Is a switch in the upper right-hand corner which establishes the units (English or Metric) for dimensional data and display.

The display section contains the LED's, drivers, and multiplexing circuits. The display information is fed to the display section two digits or 8 bits at a time. The multiplexing is done at a rate so that the flicker is not visible.

4.2 SERVO UNIT

The Servo Unit receives the digital error signal from the Controller and provides the power to drive the servo motor to the required position. Figure 4-7 shows the Servo Unit mounted to the left-hand side wall of a press brake. Figure 4-8 is a closeup picture of the

same Servo Unit with the cover removed. The Servo Unit includes its own power supply, which receives AC power when the key switch in the controller is turned to "ON".

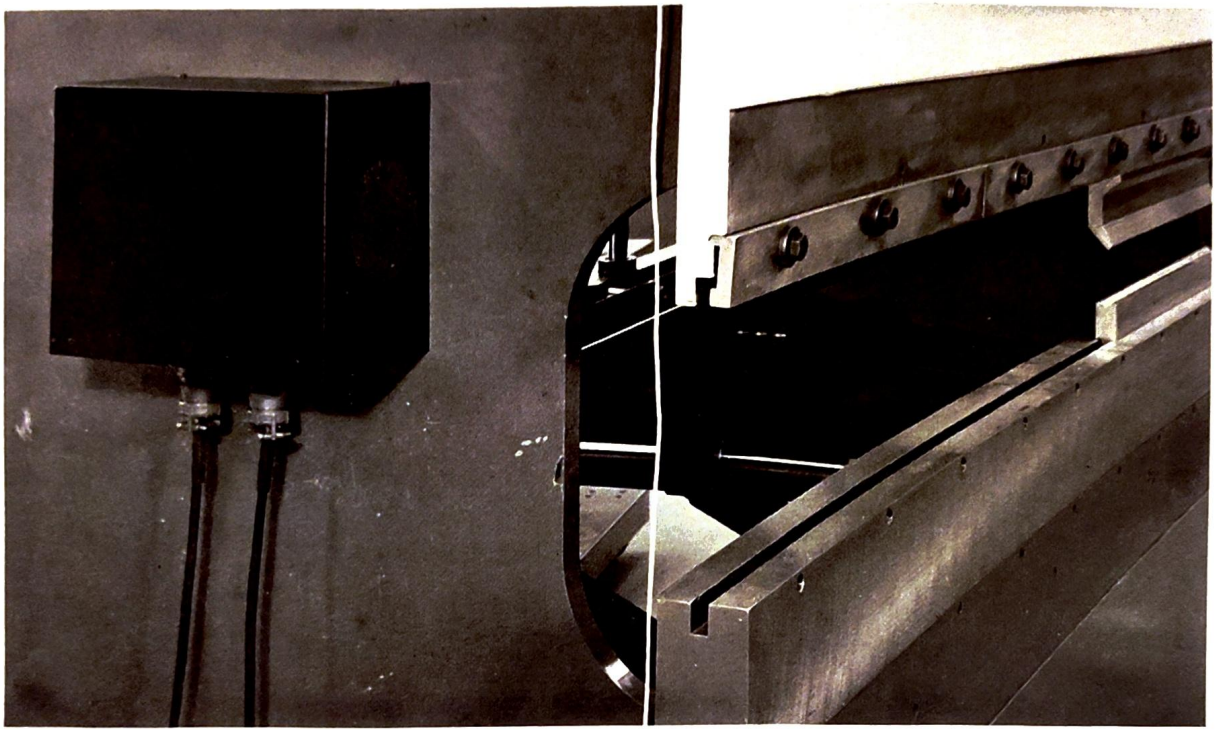


Figure 4-7

As described in the previous section, the controller compares the present position of the back gauge to the command position, and generates an 8-bit parallel digital error signal that becomes the input to the Servo Unit. The 8-bit error signal is identified as follows:

1. Sign bit – direction of required motion.
2. Fast slew – constant-velocity command whenever position error is greater than approximately 0.8 inch (20 mm).
3. Fast slew complement.
4. Slow slew – lower constant-velocity command whenever position error is less than 0.8 inch (20 mm) and greater than 0.003 inch (actually 7 counts at 0.01 mm per count, or 0.07 mm).
5. Slow slew complement.
6. Final position error least significant bit.

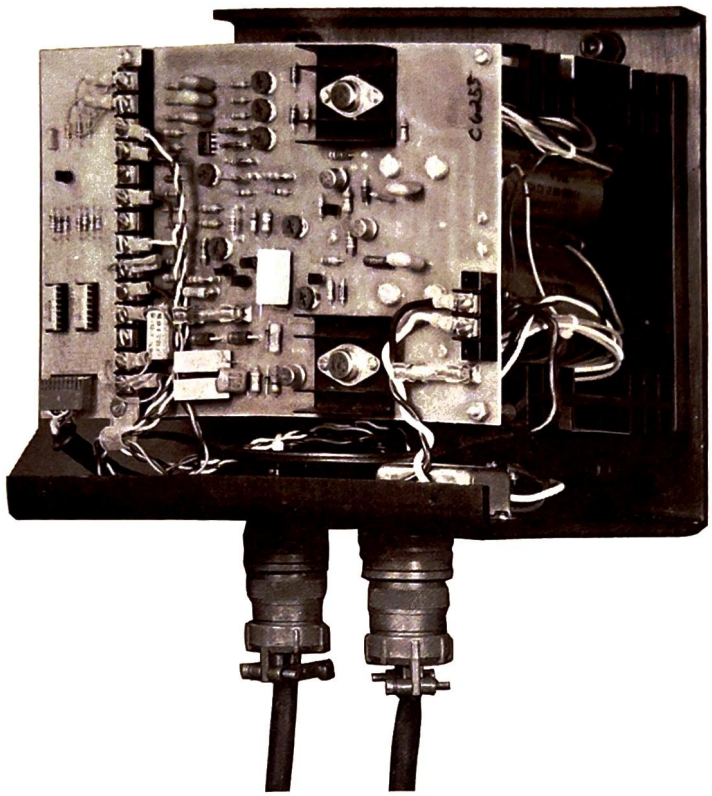


Figure 4-8

7. Final position error second least significant bit.

8. Final position error third least significant bit.

This error word is received by an interface board (Figure 4-8) which is separately removable from the Servo Unit. When a fast slew command is received, the interface board combines this with the sign bit and sends a DC voltage of the correct polarity to the servoamplifier. The motor accelerates up to the prescribed fast slew speed, at which point the tachometer feedback signal reaches a level equal to the DC input voltage and opposite in sense. As the back gauge approaches its commanded position, the slow-slew bit appears at 0.8 inch error and the DC input voltage drops to a lower level, resulting in a deceleration to about one-tenth of the fast slew velocity. During the slew modes the three least significant error bits have no effect on the signal input to the servo. Final positioning is accomplished by switching in a digital-to-analog converter that receives the three LSB's and provides the only error signal then connected to the servo. This error signal reaches zero level at the commanded position, and will then increase with a change of sense if the sign bit indicates an overshoot. Then the error will settle into a stable null at the commanded position.

The servoamplifier consists of an operational amplifier that receives three inputs: (1) the DC tachometer which provides dynamic damping and a velocity reference for slew control, (2) the DC slew inputs which switch from high to low levels and then to zero in final positioning, and (3) the final position error which appears only when the actual error is between ±0.003-inch. The three inputs have separate gain control which are factory set for dynamic stability, slew velocity levels, and position loop stiffness. The operational amplifier output signal becomes the input to the power amplifier, which in turn generates the drive current to the DC servo motor. The power amplifier is limited to peak current signals of 20 amperes, which occur only during starting and stopping. Slew currents run typically 3 to 5 amperes.

The operational amplifier includes an adjustable lag-lead dynamic compensation circuit that is also factory set for tach-loop stability.

The Servo Unit contains its own power supply providing ±40 volts DC for the power amplifier. Two fuses are mounted in holders on the amplifier board, one for the AC input power and the second in series with the servomotor. Both are 5 ampere, slow blow, 3AG Littlelfuse type #313005H.

4.3 MECHANICAL COMPONENTS OF THE BACK GAUGE

Figure 4-9 shows an isometric view of the back gauge mounted to a press brake. Flat stock is shown inserted between the dies and butted against the gauge stops mounted on the gauge bar. The dimension to be controlled is the distance between the centerline of the dies and the gauge stop faces.

Figure 4-10 is a plan view of the installation which identifies the major components that operate to set the controlled dimension to any prescribed value. The servo motor is directly coupled to the drive shaft through a flexible coupling to allow minute misalignments and runout between the motor shaft and drive shaft, but with high torsional stiffness. The drive shaft is a stainless steel solid shaft on which is mounted a husky linear actuator (Figure 4-11) which will drive the gauge carriage as the shaft rotates. This type of actuator, manufactured under the trade name Rohlix by Barry Controls of Watertown, Massachusetts, has two characteristics that are important to the operation of the back gauge system. It is virtually free of backlash and hence allows an exceptionally tight control loop with very high stiffness against any possible load effects from material being pushed against the gauge stops. The second useful characteristic provides a factory adjustable slip force level for high shock loads that may occur when heavy material is swung into position for

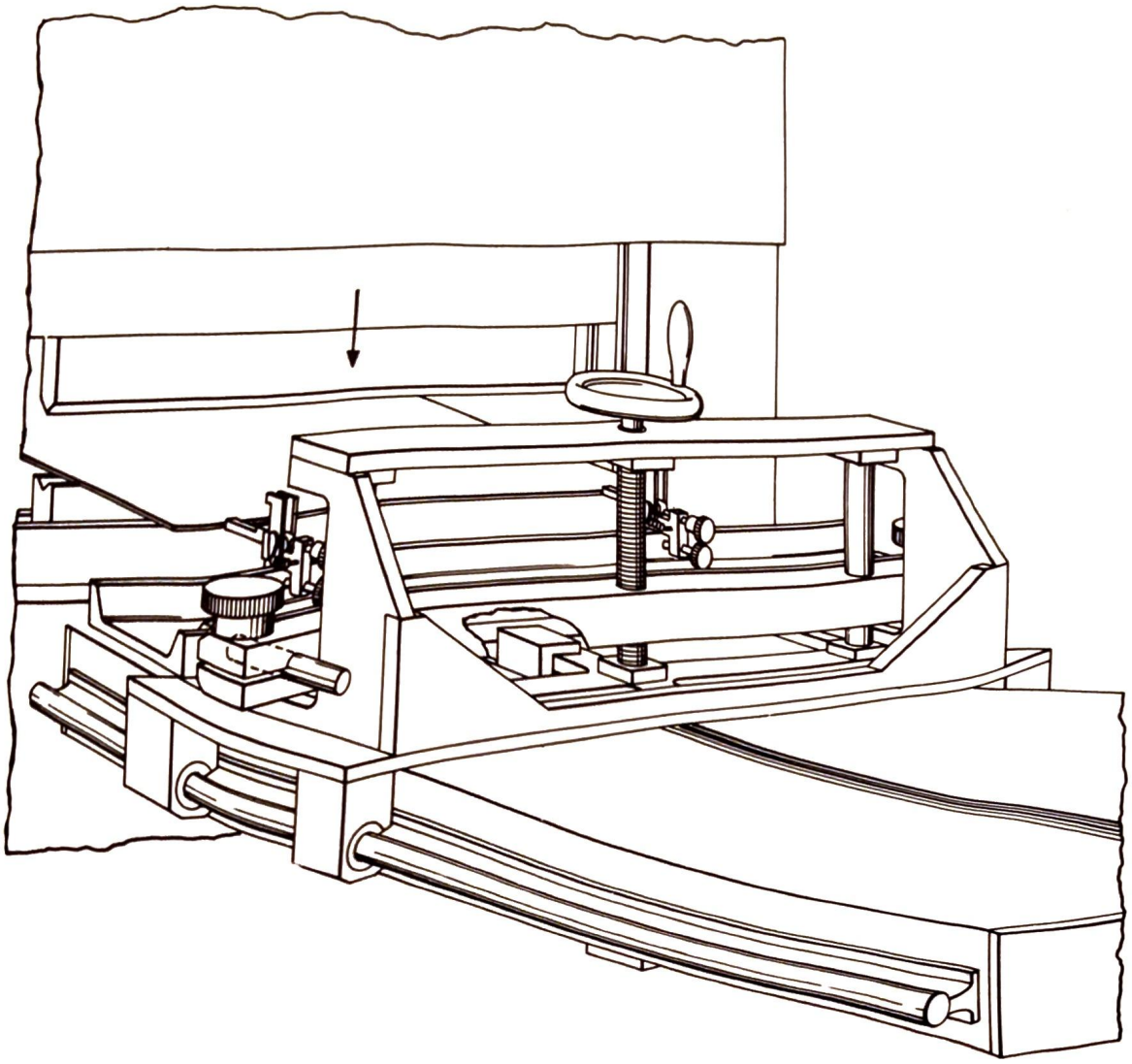


Figure 4-9

bending. On this back gauge model the slip level is set at 100 pounds, and thereby acts as a mechanical fuze protecting the drive shaft bearings and other mechanical parts in the assembly.

Figures 4-10 and 4-11 show the attachment of the linear actuator assembly to the moving sensor plate of a DRC linear encoder. An important feature of the DRC Back Gauge System is that linear motion is directly measured by the linear optical encoder of a standard type in production at DRC. Thus position accuracy does not depend upon lead-screw wear, rotary couplings or stretchable drive belts, or other devices which encode rotary motion and then depend upon accurate conversion of rotary to linear motion. Also, the linear motion

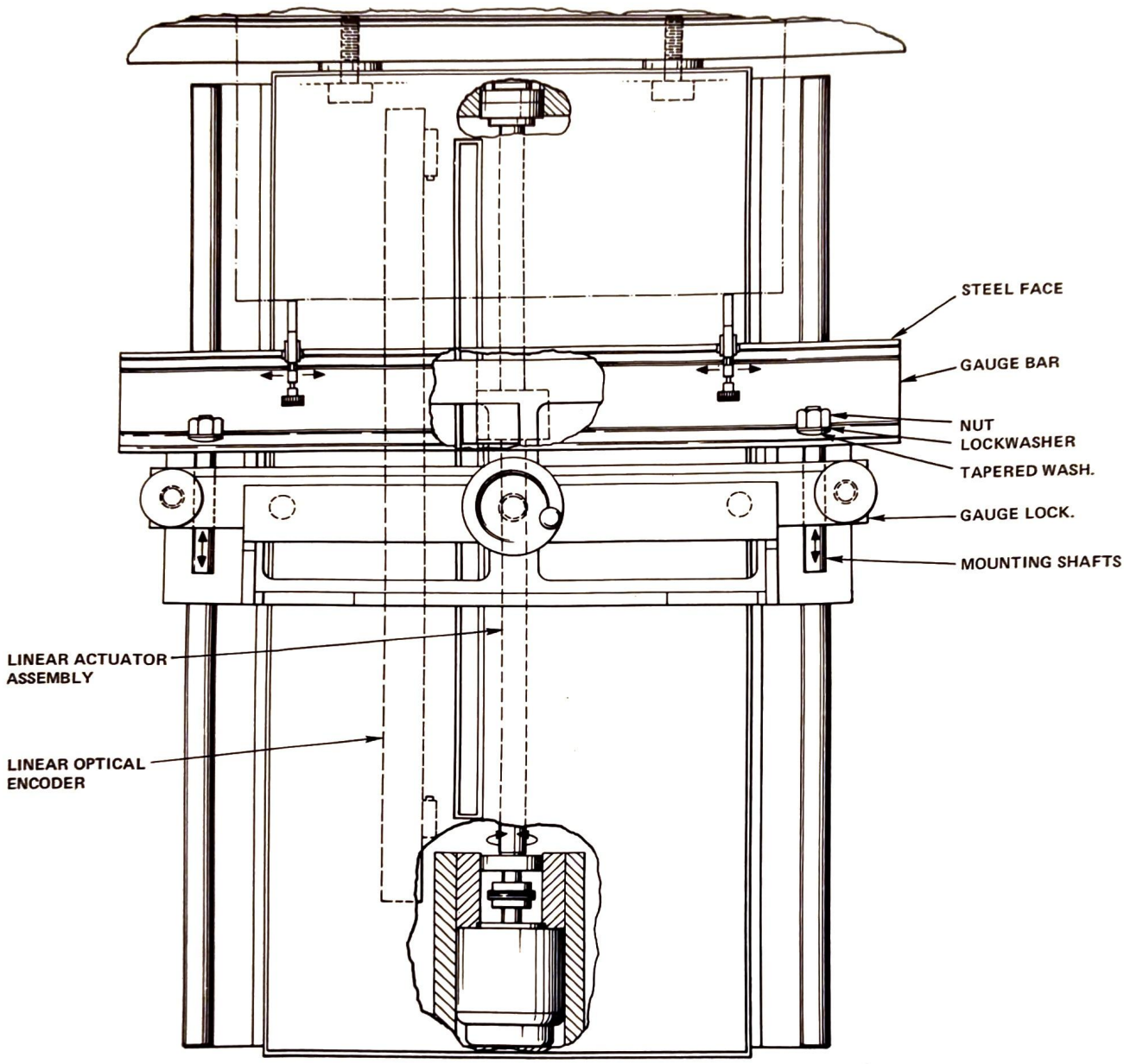

STEEL FACE
GAUGE BAR
NUT
LOCKWASHER
TAPERED WASH.
GAUGE LOCK.
MOUNTING SHAFTS
LINEAR ACTUATOR ASSEMBLY
LINEAR OPTICAL ENCODER

Figure 4-10

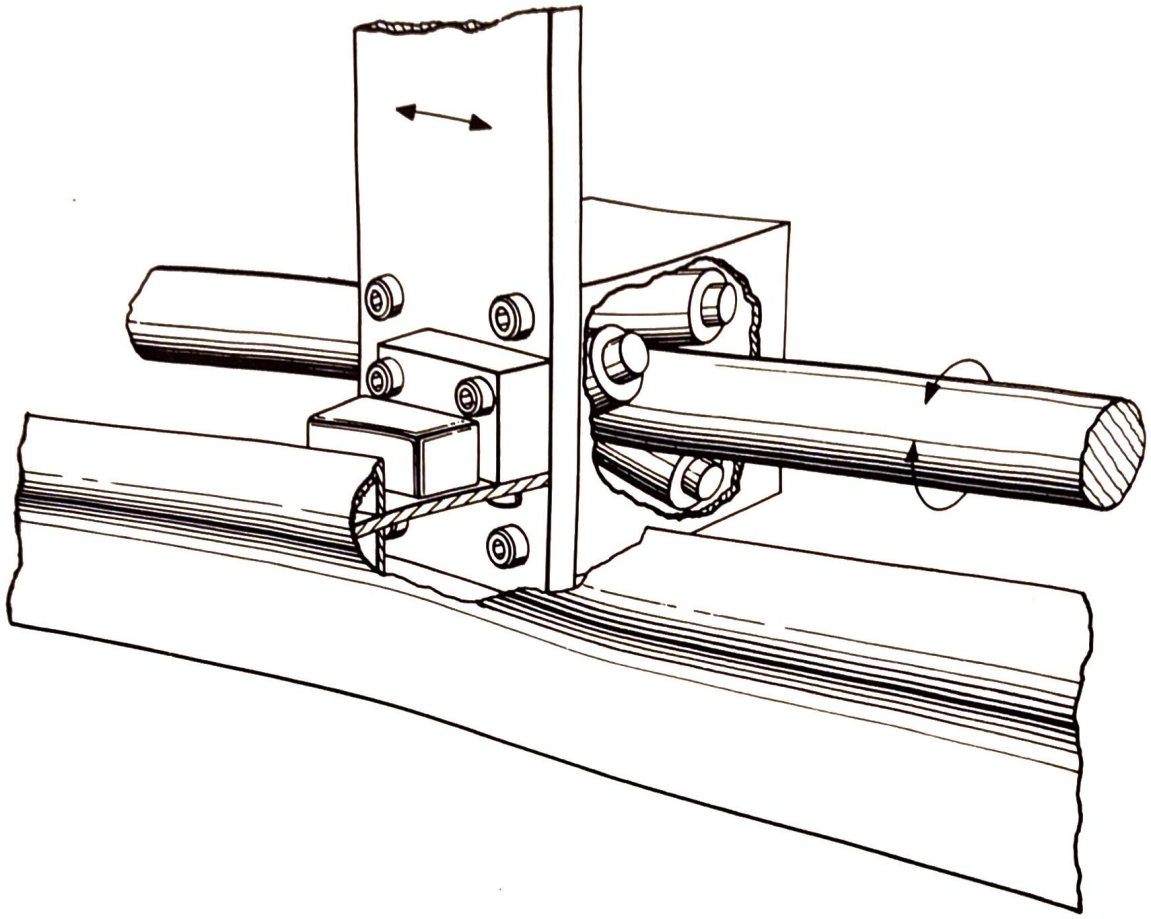


Figure 4-11

encoder permits the slip level release feature for shock loads without losing position feedback, a feature that is not possible with rotary to linear conversion systems.

As can be seen in the figures, the actuator assembly is coupled to the moving carriage through a linear flexure coupling that is extremely stiff in the direction of motion, but allows for slight misalignments between the drive shaft and the ground shafts and ball bushing bearings on which the carriage rides. The gauge bar, to which the gauge stops mount, ride on the carriage assembly and may be adjusted vertically for different die configurations and also may be adjusted horizontally to initially set a known gauge reference position.

In normal operation the material insertion dimension is established by positions of the gauge bar steel face or, when used, the gauge stop assemblies. The gauge bar is supported from the cross bar through two 1-inch diameter steel shafts. Horizontal adjustment is accomplished by releasing two massive integral clamps, built into the cross bar ends, and

manually moving the gauge bar to compensate for distance differences from bar and ram center line. Calibration range provided may be 3 to 4 inches depending on ram/die configuration.

Vertical alignment is provided by a hardened and ground screw, preloaded and centralized with two widely spaced recirculating ball bushings rolling over 1-inch diameter hardened, ground shafts (Figure 4-12). Turning the screw handcrank produces a completely smooth vertical motion. Height adjustments may be secured with a positive lock, by manually rotating a central knob for approximately one and one-half turns. Vertical adjustment and locking are each controlled with one-hand operations.

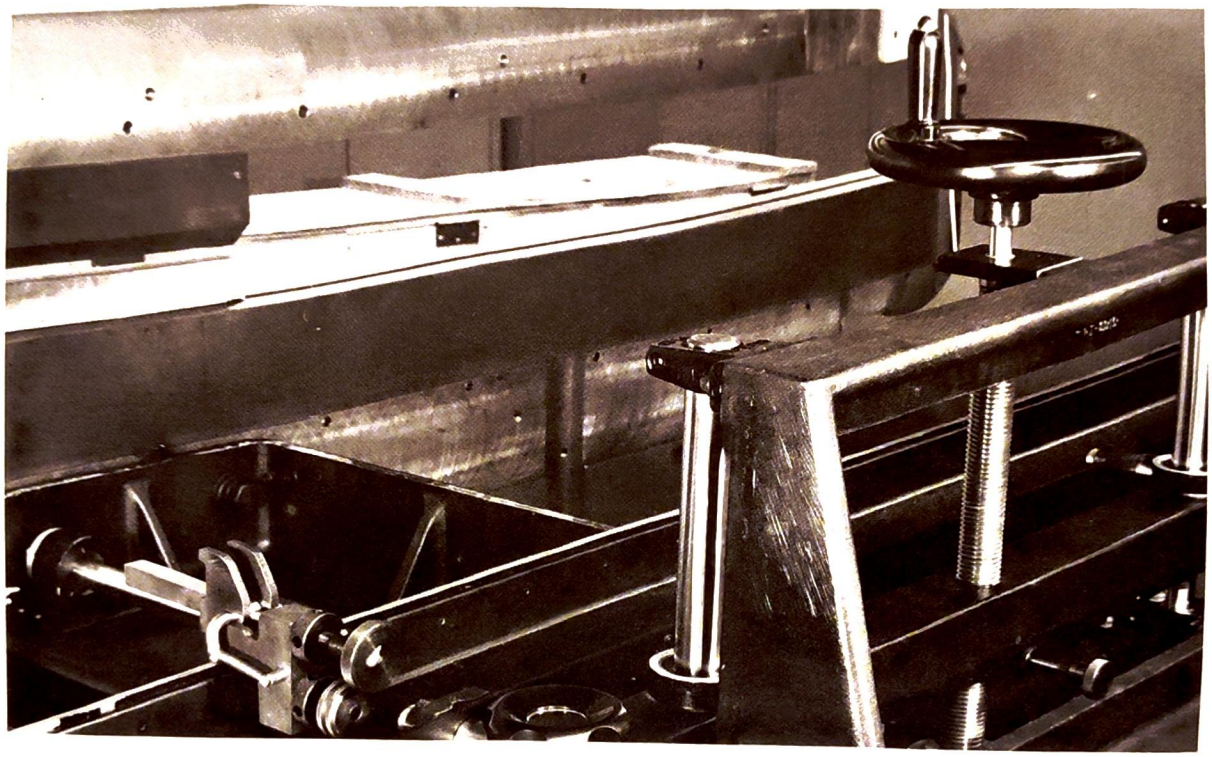


Figure 4-12

The cast aluminum carriage is supported by four oversized ball bushings and shafts (Figure 4-13), factory aligned to ensure parallel operation of the gauge bar. Two of the ball bushing housings on one side only are designed to be compliant perpendicular to the axis of motion while infinitely stiff along the axis of motion.

This feature isolates misalignments due to thermal expansion of dissimilar metals and is effective in maintaining straight line accuracy over a large temperature range.

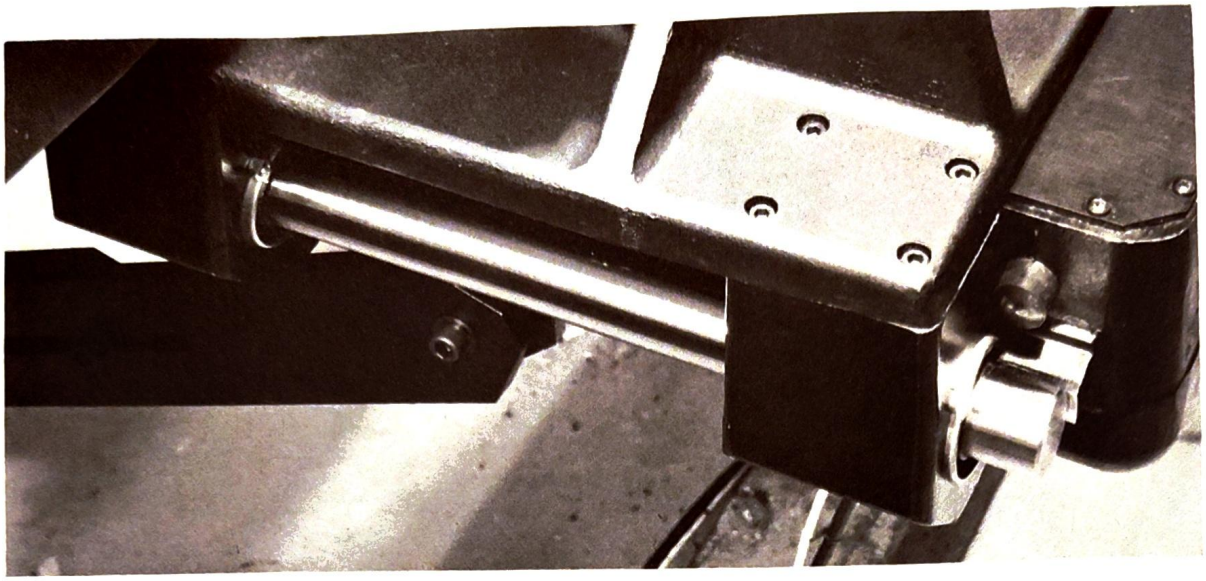


Figure 4-13

The whole mechanical system is designed to be especially rigid and durable for use in press brakes over a wide range of sizes and capacities. The heavy duty ball bushings are amply spaced to provide large moment-load capability, and the 1 1/4-inch ground shafts are larger than those found in most back gauge systems that are limited to lower capacity press brakes. The drive shaft is supported at the front end by a pair of preloaded duplex ball bearings with thrust load capacity many times the slip level set in the linear actuator. At the motor end the drive shaft is contained in a single radial contact bearing that is free to translate in the axial direction in compliance with any differential thermal expansion between the steel shaft and the heavy cast aluminum housing. The servo motor is rated for peak and continuous duty performance that is several times greater than that required in normal operation of the back gauge system.

To check power supply voltage, slide cabinet out on left side of cabinet, find test points test +5 to ground it must be 5.3 min to adjust voltage turn pot clockwise to raise voltage

5. MAINTENANCE

CAUTION: Read Section 3.1.1 and understand the power ON-OFF states of the back gauge before attempting any maintenance or cleaning.

Performing general maintenance at regular intervals on the back gauge and controller will reduce the probability of catastrophic failure of the system and increase its life.

5.1 PREVENTIVE MAINTENANCE

The two Thompson shafts shown in Figure 5-1 should be wiped clean periodically to prevent dirt buildup between the shaft and housing.

The Rohlix shaft should be wiped with a clean cloth, dampened with alcohol, to remove deposits left by the Rohlix itself.

The vertical shafts on the upper carriage and the gauge bar edge should be wiped with a clean cloth dampened with micro oil.

The mounting hardware should be checked to insure that it is tight and that no cabling is damaged.

The controller requires a battery change about once a year, possibly more often if long AC power failures occur. Otherwise, it is best to stay out of the controller.

5.2 CLEANING

Cleaning that was not covered in the preventive maintenance section can be accomplished with a damp cloth and a mild detergent.

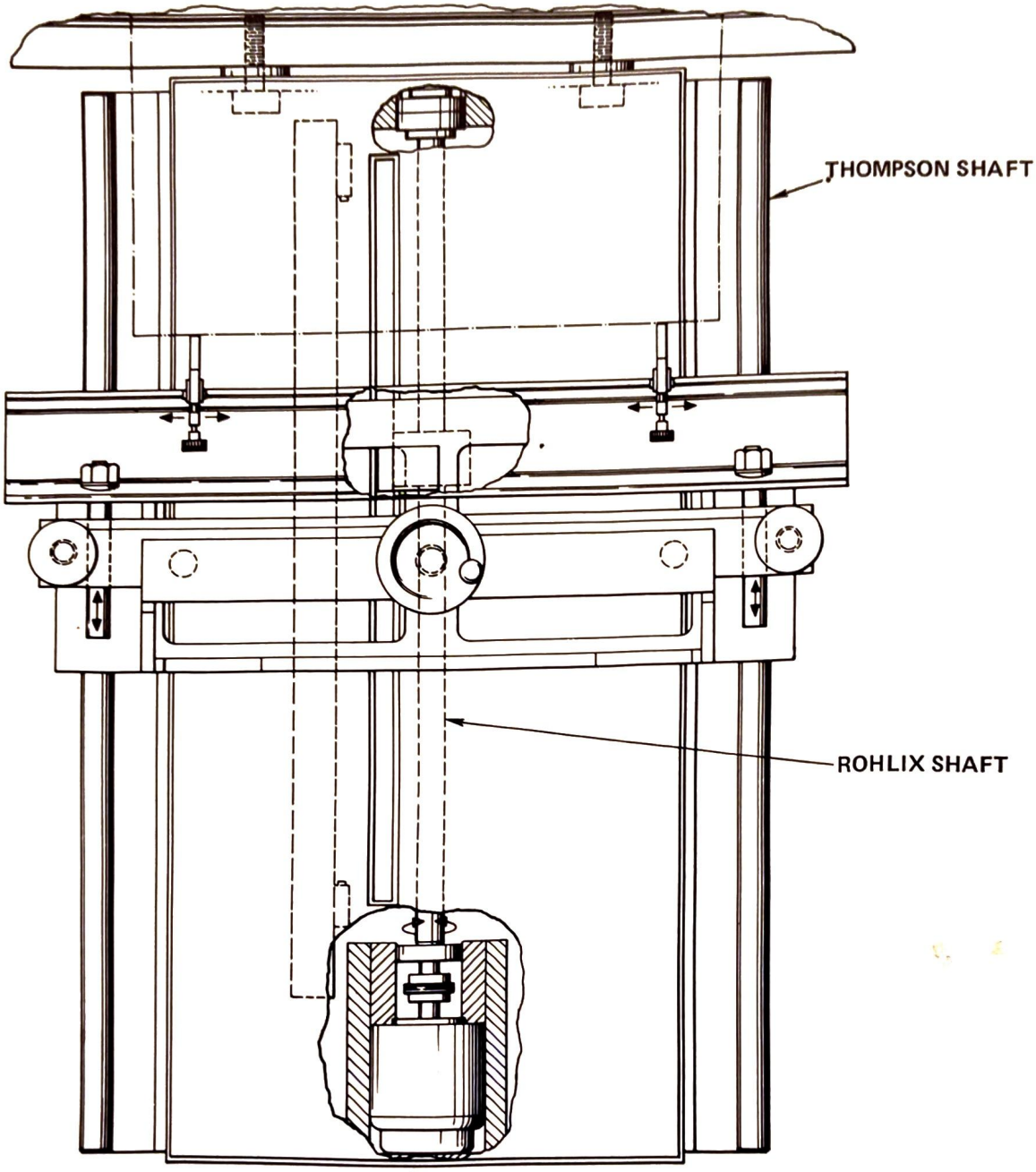


Figure 5-1

5.3 LUBRICATION

Lubrication other than what was discussed in the preventive maintenance section is not required.

CAUTION: Do Not Lubricate the Rohlix Shaft.

5.4 TROUBLESHOOTING

The first step in correcting a system problem is to properly identify the malfunction. This section is an attempt to assist you in doing that.

5.4.1 Preliminary Check

1. Verify that all external wiring is still plugged in. Do this by actually trying to turn connectors to insure that they are tight. Also, verify that the thumb screws that hold the controller into the controller case are still tight.
2. With the servo switch on the back of the back gauge OFF, check to see that the Rohlix shaft is turning freely.
3. With the servo switch on the back of the back gauge OFF, turn power back on and clear all entries to controller.
4. Turn power to servo motor ON and follow the normal start-up procedure.

If normal operation cannot be accomplished, check the following list of symptoms to locate your problem.

SYMPTOM	*CHECK*
1. Display will not light up.	1. 110 volts available 2. Controller key switch on 3. Controller fuse.
2. The calibrate key does not blink when AC is reestablished.	Ram switch (make sure it is closed).
3. Continually runs into stops.	Dimension-Bend Allowance is less than zero or greater than 27 inches.

SYMPTOM	*CHECK*
4. Servo will not drive.	1. Check for power on motor by trying to push upper carriage. If it moves and stays in position, you have no power to motor. 2. Remove cover from servoamplifier and check fuse.
5. Servoamplifier blows fuses.	1. Check for mechanical interference. 2. Insure Rohlix shaft turns freely.
6. Servo motor oscillates with loud noise.	Gain adjustment in servoamplifier is incorrect.
7. Unit makes loud noise when moving to new position.	Loose coupling.
8. Unit will not automatically step through sequence.	Ram switch not making contact.
9. Controller will not accept entries.	1. Not in Enter or Idle mode. 2. Back gauge did not arrive at previously programmed position.

Programming Don'ts

1. Do not program a bend allowance greater than the dimension.
   Result: the carriage will run into the stops.
2. Do not subtract a number greater than the dimension in that given step.
   Result: the carriage will run into the stops.
3. Do not program a number greater than 27 inches.
   Result: the carriage will run into the stops.
4. The only way the controller will recognize "zero" is if when combining two programs you accidentally insert zero in the first step of the second program.
   Result: the carriage will run into the stops.

When the carriage runs into the stops, do the following:

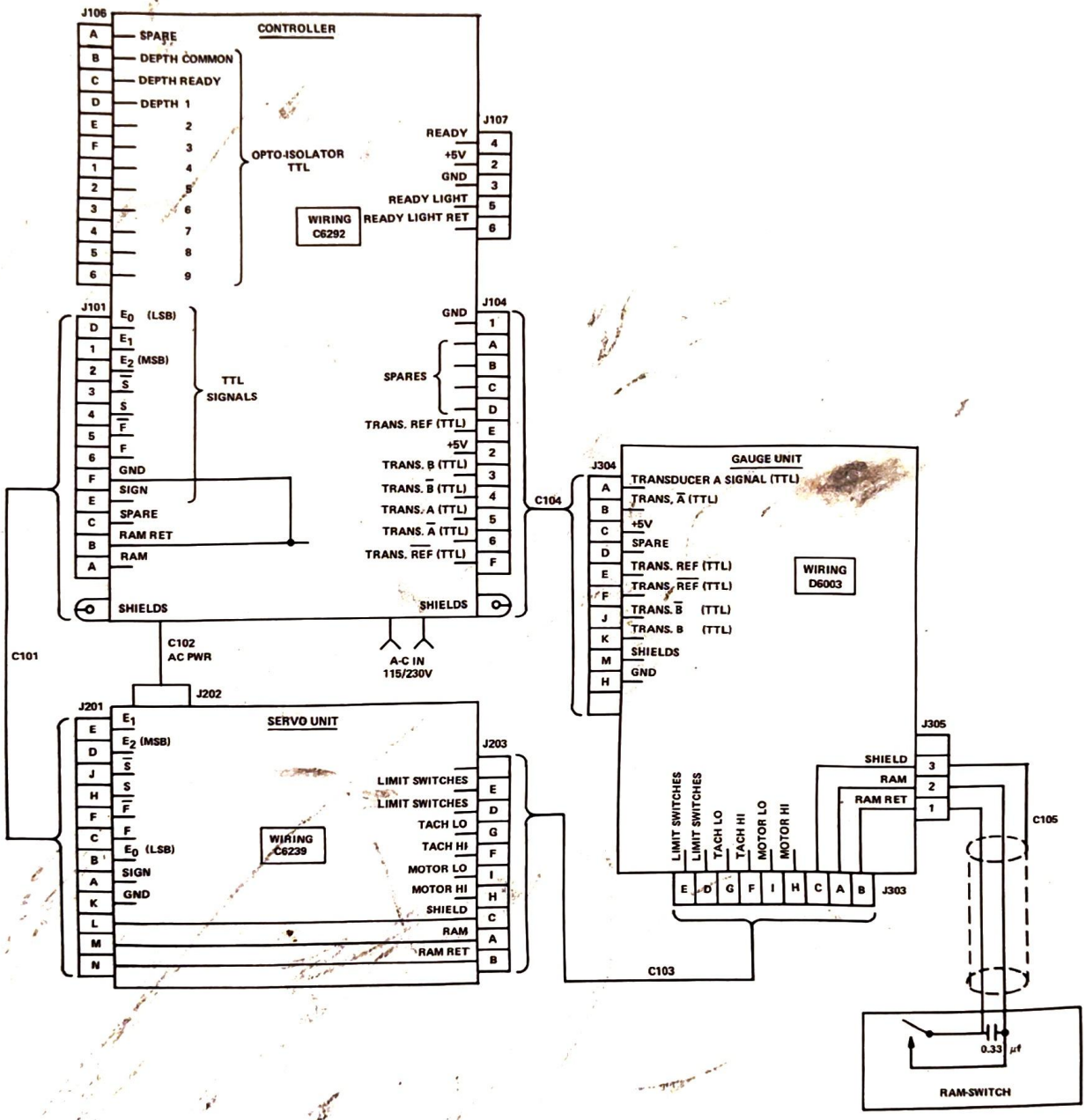
1. Press the stop button.
2. Turn the controller key off.

3. Push the carriage off the stops.

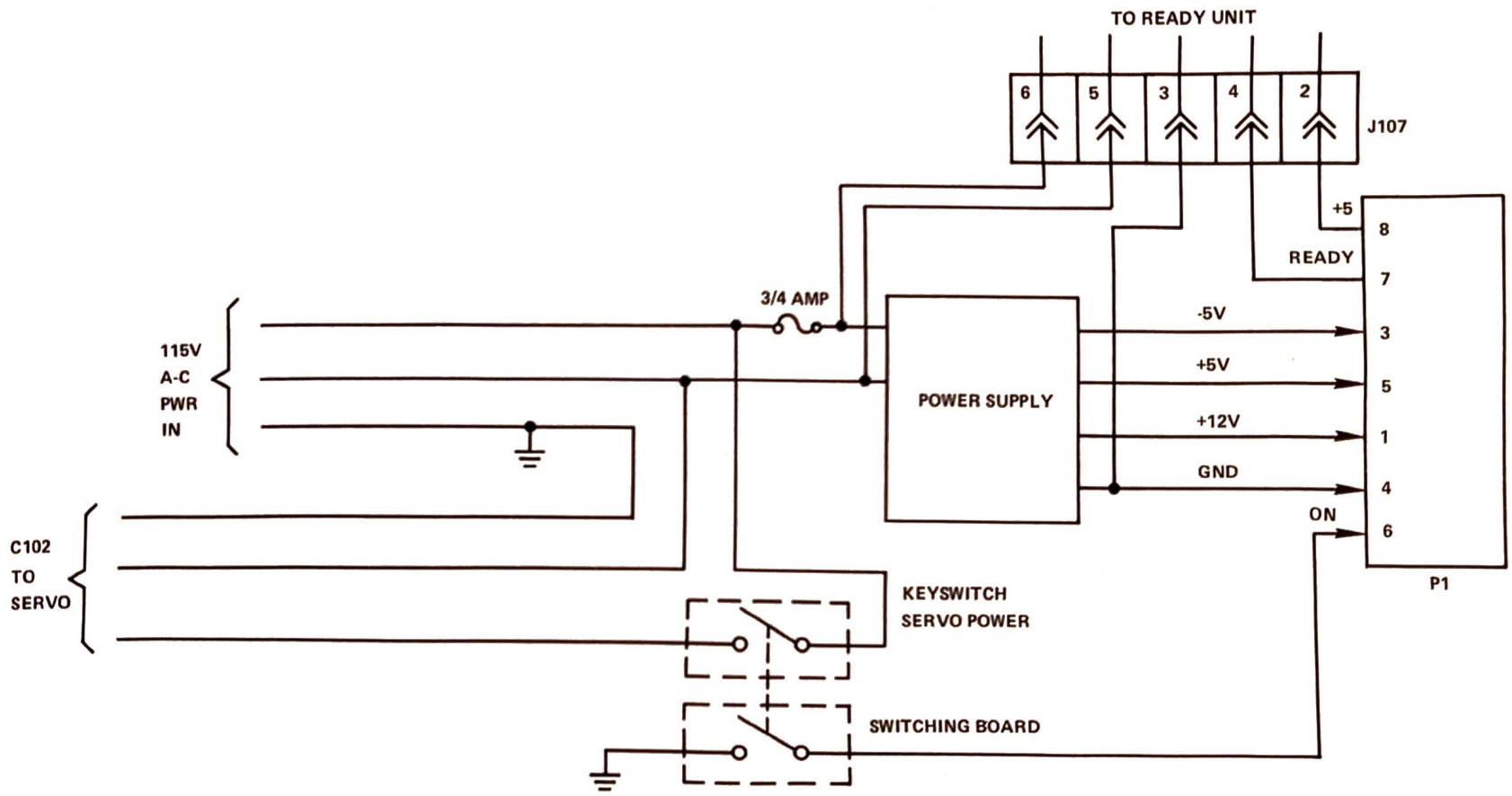
4. Turn key back on.

The controller should come on in either "enter" mode or the "calibrate" light should be flashing. However, calibrate and check the stored programs.

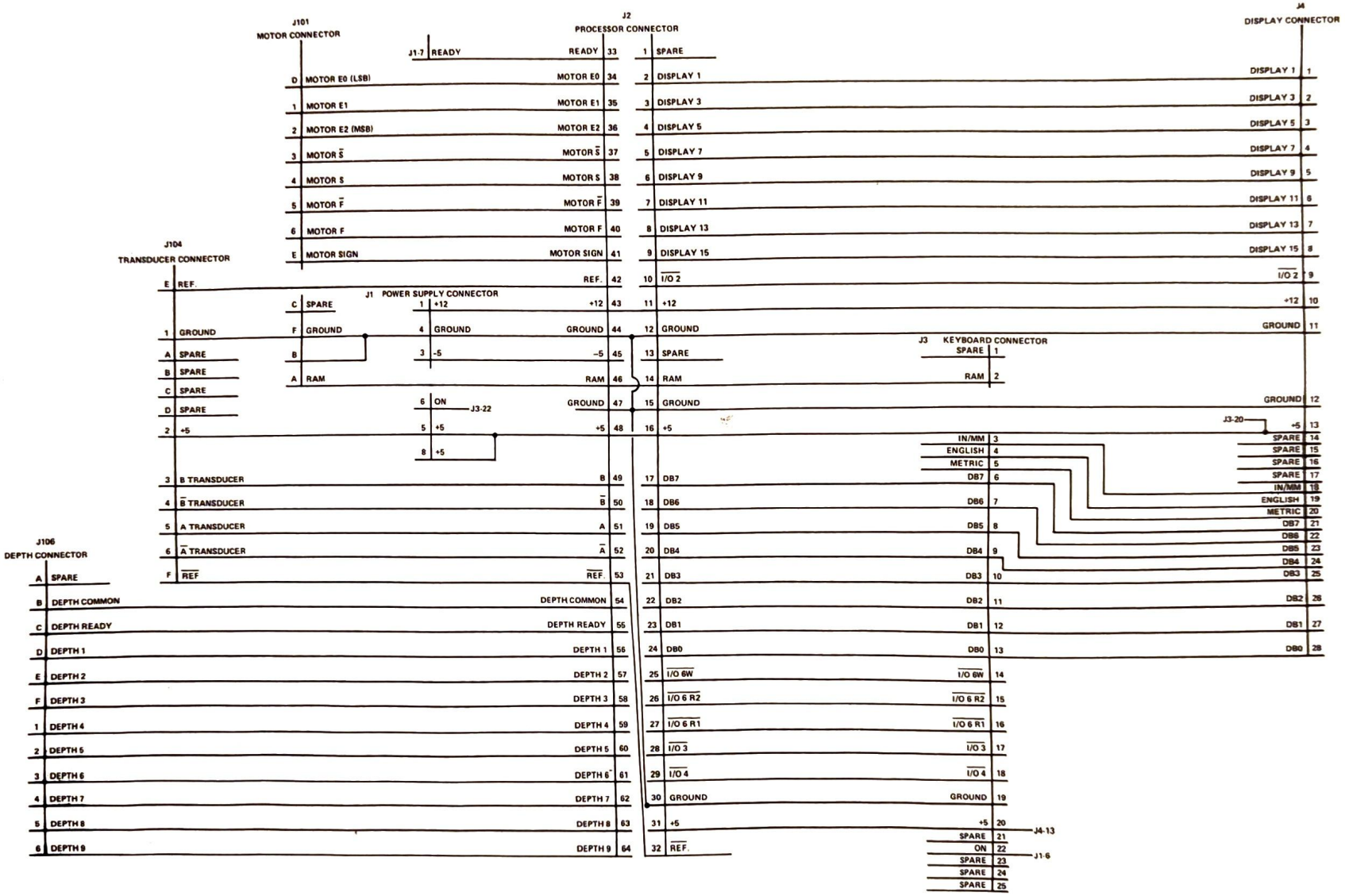
BACK GAUGE SYSTEM CABLING SCHEMATIC



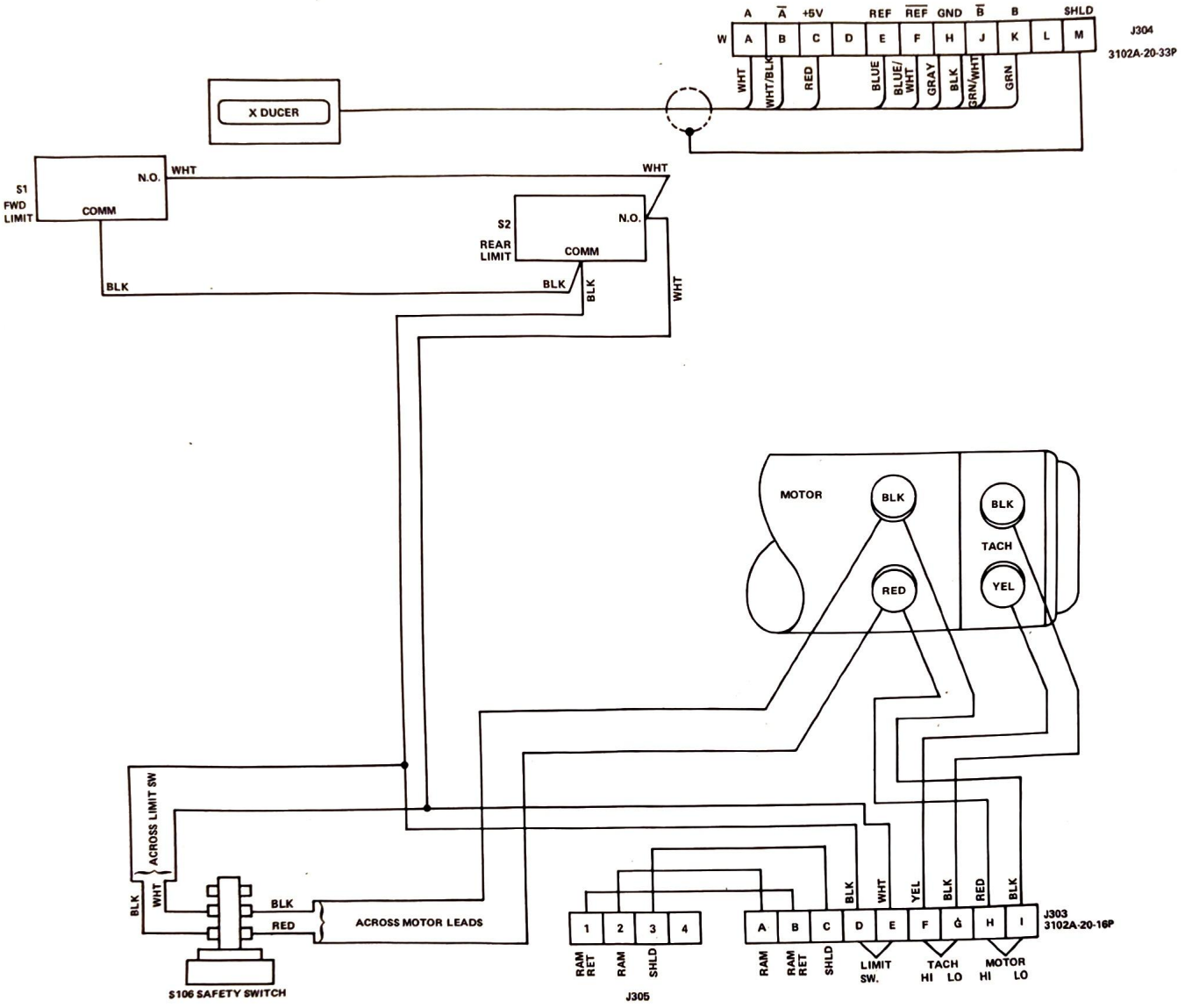
CONTROLLER POWER SCHEMATIC



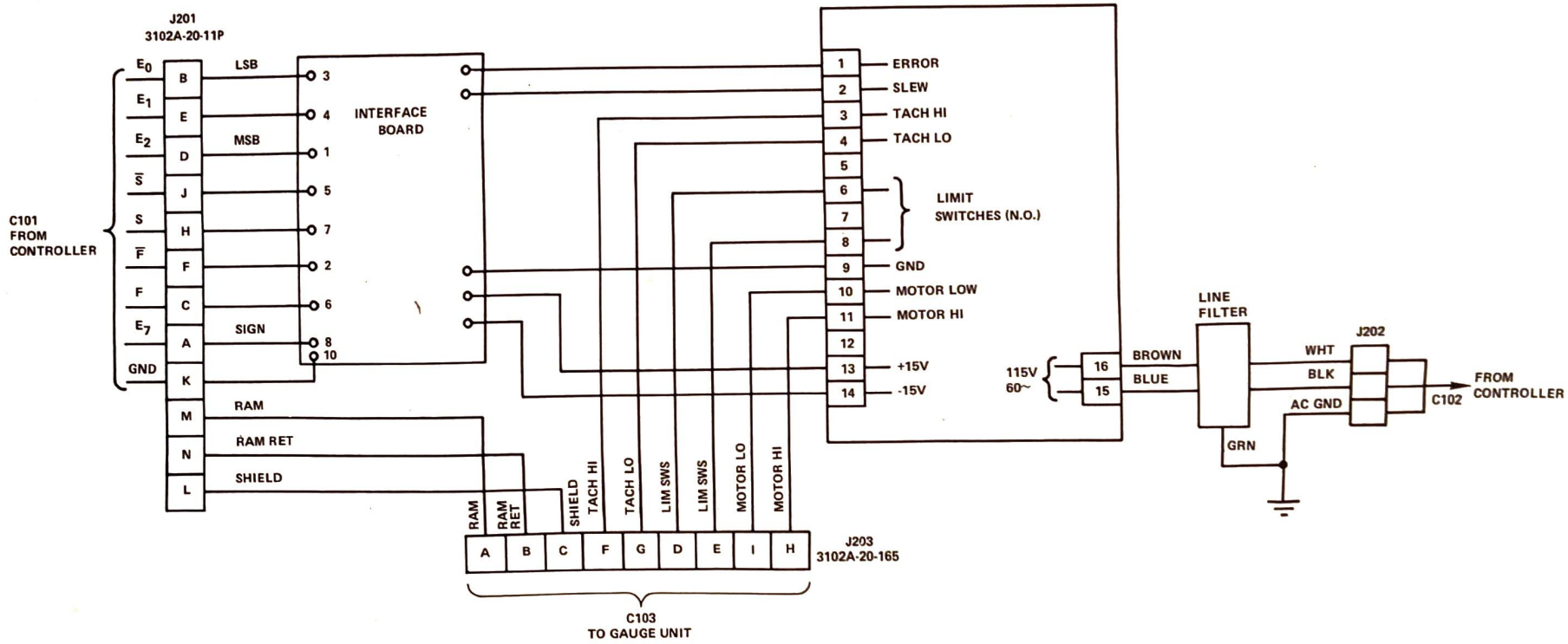
CONTROLLER PARENT BOARD SCHEMATIC



GAUGE UNIT WIRING SCHEMATIC



SERVO UNIT WIRING SCHEMATIC



DRC
DYNAMICS RESEARCH CORPORATION
60 CONCORD STREET, WILMINGTON, MASSACHUSETTS 01887 TEL. 617/658-6100 COMPONENTS DIVISION

TO : Distributor Sales, Regional Sales and Installation

FROM: DRC Customer Service

RE : Installation Backgauge

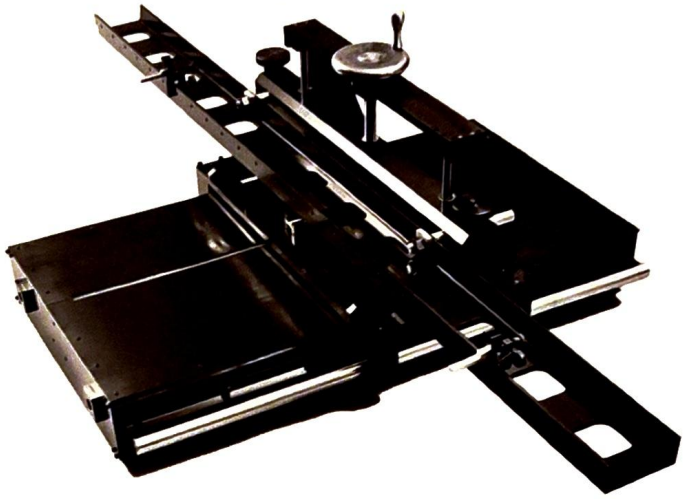
DATE: March 10, 1977

RECOMMENDED AC LINE SERVICE TO CONTROLLER

AC Line cord must be plugged into 3 wire receptacle with proper earth ground. Separate service external to press brake is recommended.

Do not allow conduit run, for AC line service of controller, to ENTER/EXIT press brake control box. Exposed, unshielded AC wires can pick up radianted electrical interference from internal sources of control box. This can cause erratic movement during backgauge positioning.

DRC AUTOMATIC BACK GAUGE SPECIFICATIONS



Back Gauge Specifications

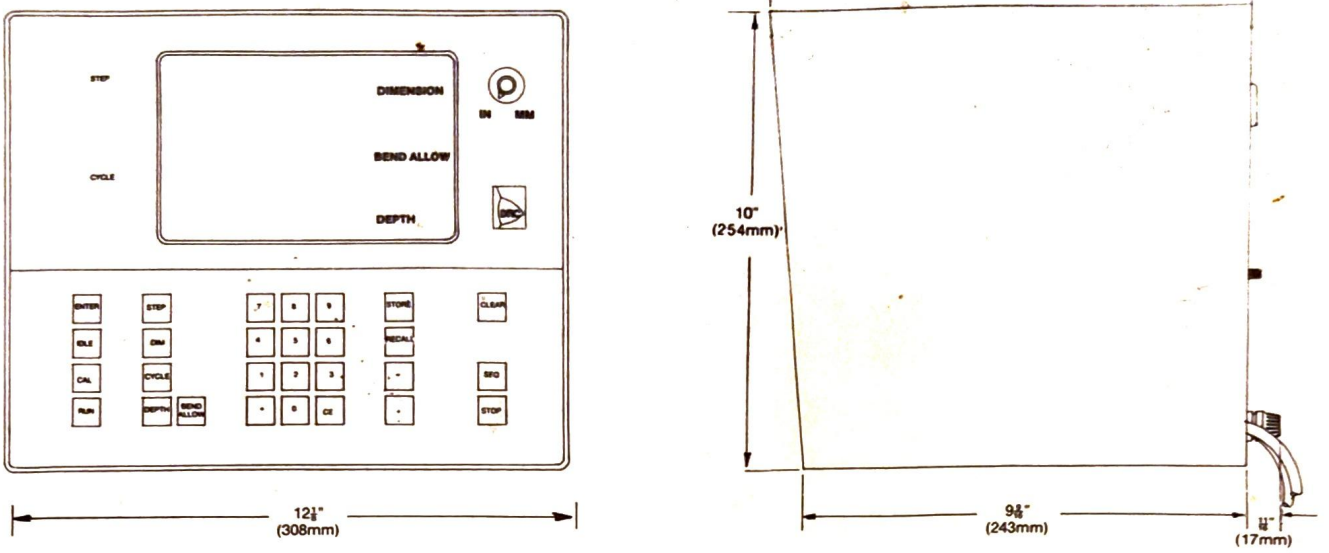
Capacity:	Suitable for press brakes bending up to 3/16" (4.8mm) sheet thickness. Rear mounted only.
Maximum Travel:	27" (686mm)
Length of Gauge Bar:	Optional lengths from 33" (838mm) to 99" (2515mm)
Vertical Adjustment:	6" (152mm)
Horizontal Calibration Adjustment:	4" (102mm)
Resolution:	.001" or .01mm
Accuracy:	± .002" (± .05mm)
Repeatability:	± .001" (± .03mm)
Speed:	720"/min (18.3M/min) with automatic slow down at dimension.
Overall Width:	33.25" (845mm)
Overall Depth:	47" (119mm)

Controller Specifications

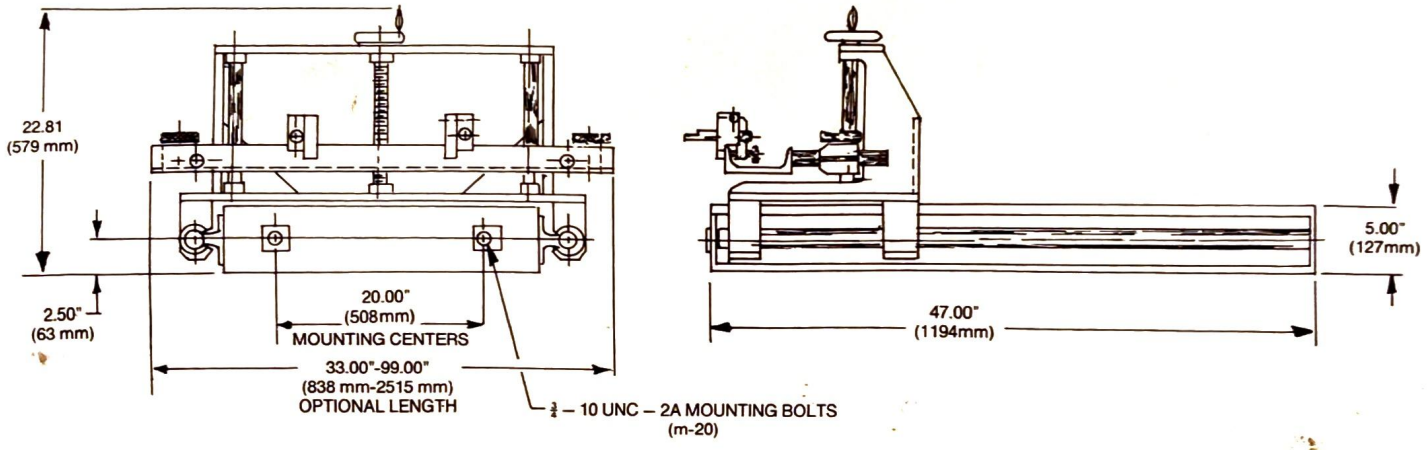
Program Capability:	Keyboard data entry and display of step, dimension, cycle, bend allowance and optional depth control.* Capacity to store up to 9 different programs. Each program can have up to 9 gauge positions (steps) with up to 9 repeat dimensions (cycles) or program up to 72 moves sequentially. Converts data entries from inches to millimeters or millimeters to inches. Recharging battery system retains programs in memory up to 2 weeks in the event of power loss.
Input Power:	110V single phase 4A 50/60 hz (220V available for foreign use only)
Shipping Weight:	Approximately 500 lbs (225 kg)

*When used in conjunction with hydraulic press brakes equipped with electrical switches for multiple depth settings. Select up to 9 preset depth settings for synchronization with gauge position.

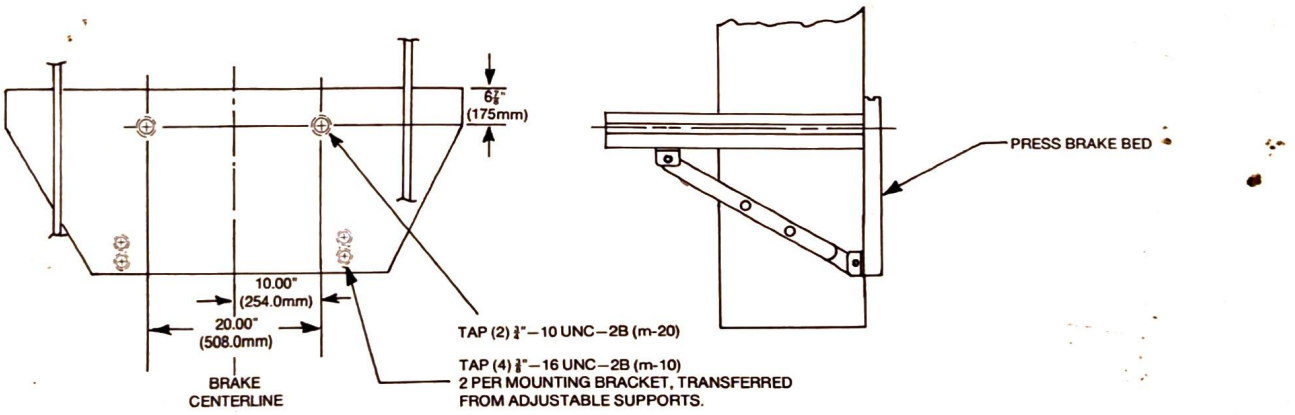
Outline Drawing Controller



Outline Drawing Back Gauge


22.81 (579 mm)
2.50" (63 mm)
20.00" (508mm) MOUNTING CENTERS
33.00"-99.00" (838 mm-2515 mm) OPTIONAL LENGTH
¾ – 10 UNC – 2A MOUNTING BOLTS (m-20)
5.00" (127mm)
47.00" (1194mm)

Installation Procedure


6½" (175mm)
10.00" (254.0mm)
20.00" (508.0mm)
BRAKE CENTERLINE
TAP (2) ¾"–10 UNC–2B (m-20)
TAP (4) ⅜"–16 UNC–2B (m-10) 2 PER MOUNTING BRACKET, TRANSFERRED FROM ADJUSTABLE SUPPORTS.
PRESS BRAKE BED

Dynamics Research Corporation

Precision Measurement Division
60 Concord Street, Wilmington, MA 01887
Telephone (617) 658-6100/TWX: (710) 347-0299

Warranty: DRC warrants the Automatic Back Gauge against defects in material and workmanship under normal and proper use and service for a period of ONE YEAR on both parts and labor.

BULLETIN #1

FAIL SAFE MODE

A portion of the program which is in the automatic backgauge controller eliminates most of the programming don'ts. In other words, incorrect programming will be rejected without driving the reference bar. However, if the carriage runs into the stops it is a result of an unforeseen programming error or excessive overshoot of the carriage due to the tac-gain of the servo amp set too high. This is the fail safe mode.

About 1/8" before the carriage hits the stops the carriage trips a micro switch which disconnects power to the servo motor itself. This safety feature protects the servo motor and shaft coupling from either electrical or mechanical damage.

If your unit does run into the stops, do the following:

1. Press the stop button in the controller.
2. Turn the controller key to OFF.
3. Turn off backgauge switch located at the rear of gauge.
4. Push carriage off stops.
5. Turn gauge switch on.
6. Turn controller key on.

The controller will come on either in ENTER mode or CALIBRATE light will be flashing. Hit the CALIBRATE button and recheck your stored programs for correct input data.